ELECTRICAL ENGINEERING

Registered United States Patent Office

JUNE
1953

The Cover: Old "Absecon" Light near Atlantic City, now maintained as a symbol, stands 167 feet above sea level and was originally lighted with whale oil. Present lighting consists of one 3,000-watt type-*AH9* mercury-vapor lamp in a Westinghouse industrial reflector-type luminaire suspended vertically within the optical assembly of the Fresnel lens used as the directional beacon, but shielded seaward and generating 120,000 lumens. Downward floodlighting for the shaft itself employs four 1,000-watt type-*AH12* 55,000-lumen mercury-vapor lamps in special Westinghouse "Millite" luminaires.

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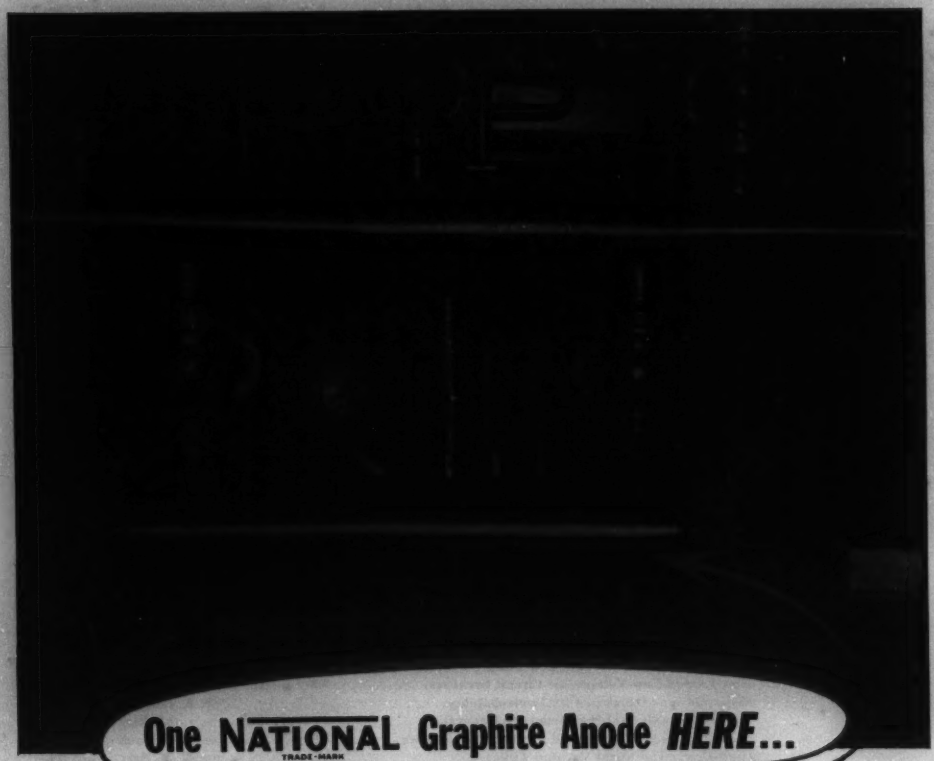

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HIGHLIGHTS .....

AIEE Fellows. Recent changes in the AIEE Constitution have made the Fellow grade available by invitation only to those who have attained distinction as a result of the importance, originality, or responsibility of their work. In honor of those members who have been elevated to this grade, a new department, "AIEE Fellows Elected," has been added to the magazine. This department will contain biographical sketches, summaries of outstanding achievements, and photographs of all new AIEE Fellows (*pages 560–3*).

Summer General Meeting. This month's cover, featuring Old Absecon Light on the northeastern end of Absecon Island, now Atlantic City, N. J., heralds the 1953 Summer General Meeting of the Institute to be held at the famed seaside resort city. Not only will the meeting present the usual comprehensive program of technical sessions, but the varied recreational facilities offered by the meeting site should make this a perfect opportunity for a week of relaxation (*pages 544–9*).

President's Address. President Quarles reports on several matters of current interest to the membership in his address at the recent Southern District Meeting of the Institute in Louisville, Ky. (*pages 477–9*).

Plastic Electrets and Their Applications. The nature and behavior of plastic electrets are presented and compared to available information on wax electrets. Engineering applications are discussed and experimental results evaluated in the light of present-day theories concerning electret phenomena (*pages 511–14*).

Management and the Engineer. "Every management plan must have as one component a concrete program for the development of people." In this article, the author considers that portion of a management plan which is concerned with the development of the engineer (*pages 497–5*).

Safety Regulations. Effects of safety regulations are felt by all segments of the electrical industry. Their applications to the field of supply and utilization of electric energy and the necessity for reasonable safety standards to minimize potential hazards to the public are discussed (*pages 480–2*).

Trends in Detection and Measurement of Radioisotopes for Medical Purposes. A review of the latest developments of radioisotopes used in medical therapy, diagnosis, and research, and the instruments which are being used for their detection and measurement is presented. Only the detection of beta and gamma radiations are considered as they are being used currently (*pages 484–9*).

Insulation Co-ordination. The opinions and methods of approach of one group of individuals working on the problem are presented in the hope that this analysis will aid in understanding the problem and promote national and international standardization of insulation levels. Although basic impulse insulation levels above 1,050 kv are not considered since preferred system voltages have not been designated, it is suggested that the same philosophy of protection be applied in establishing the higher levels (*pages 497–503*).

Nuclear Power Plant Controls. Plant operational and control requirements are discussed together with plant dynamics, other miscellaneous plant information, and component characteristics and limitations. It is concluded that a given performance can be specified for a nuclear power plant, and then the reactor and its associated equipments can be made to supply the required output (*pages 505–09*).

The XY Toll Ticketing System. The designer of an automatic toll ticketing system is confronted with the need for an inexhaustible medium on which to store temporarily the billing information until the data are printed as a toll ticket. A magnetic tape has been used successfully in the system described (*pages 517–22*).

The Reliability Required in the Petroleum Electric System. A discussion of the degree of reliability necessary for various types of refinery units is followed by the suggestion that the automatic secondary selective system be utilized to supply the most critical loads (*pages 522–4*).

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Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District Meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Principles of Load Allocation Among Generating Units. An over-all picture of present-day practice and problems reviews the present status of load division between plants and units on a power system, taking into account the last 5 years of progress in telemetering, transmission-loss determination, generator temperature capabilities, boiler temperature limitations, automatic boiler control, and automatic combustion control. Capability and reserve also are discussed briefly (*pages 526–9*).

Air-Turbine Accessory Drives. The reasons for the selection of an air-turbine drive, the problems encountered in the selection, and the methods of overcoming them are discussed. The air turbine is shown to be useful in achieving reduction of aircraft weight and complexity (*pages 530–3*).

Nickel-Base Indirectly Heated Oxide Cathodes. The authors review the possible mechanisms of emission, consider the performance characteristics of oxide cathodes, and comment on the properties of various cathode nickel alloys and their effect upon cathode performance (*pages 536–40*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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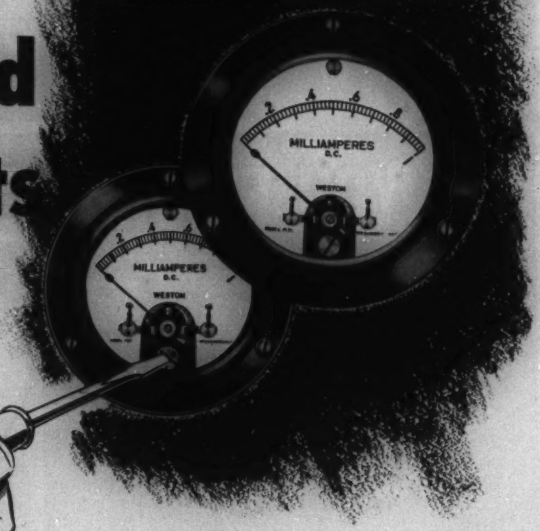

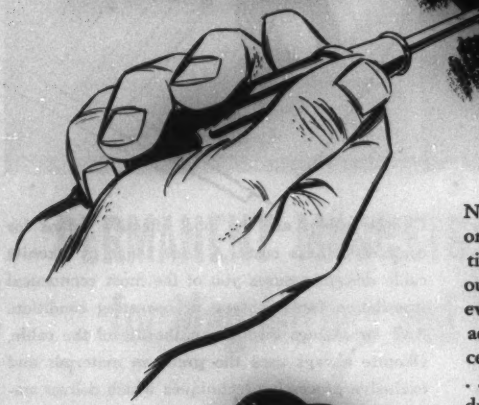

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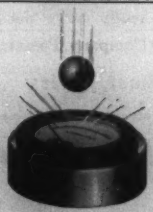

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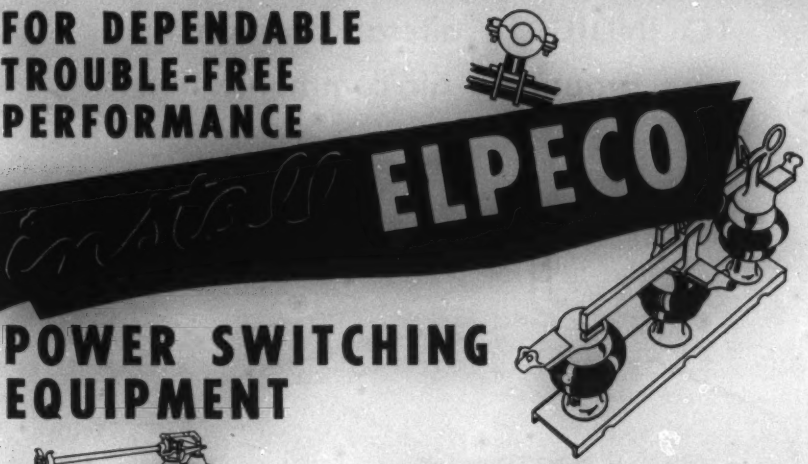

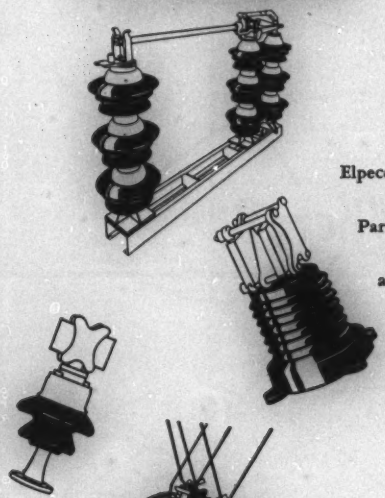

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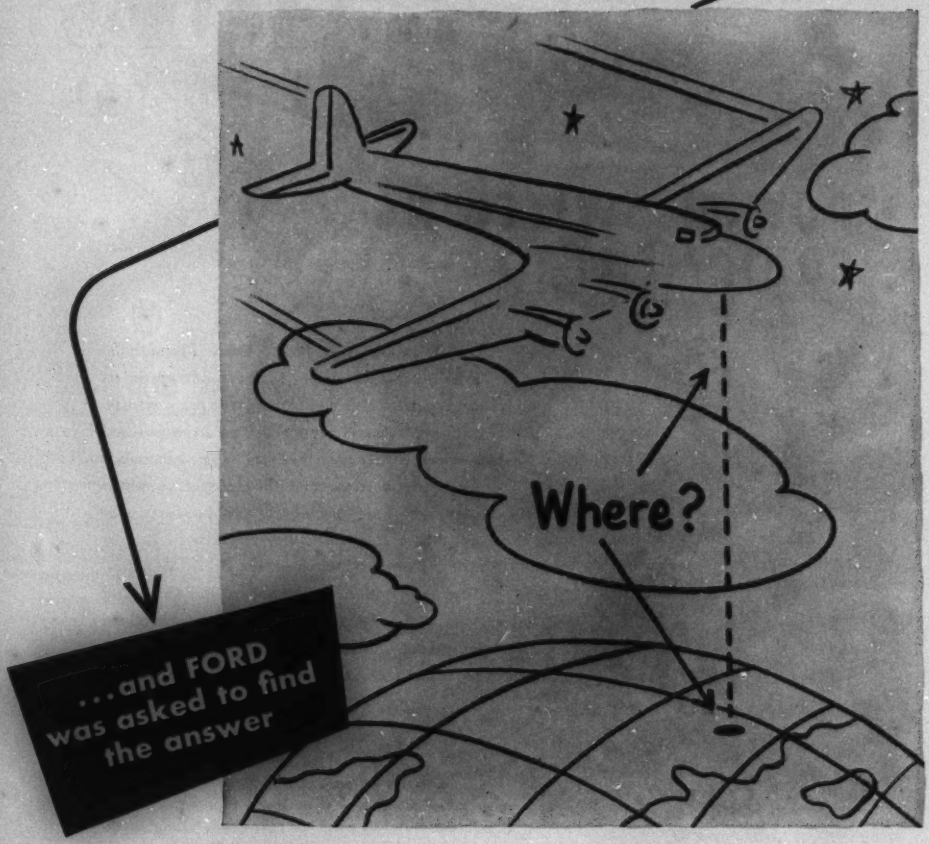

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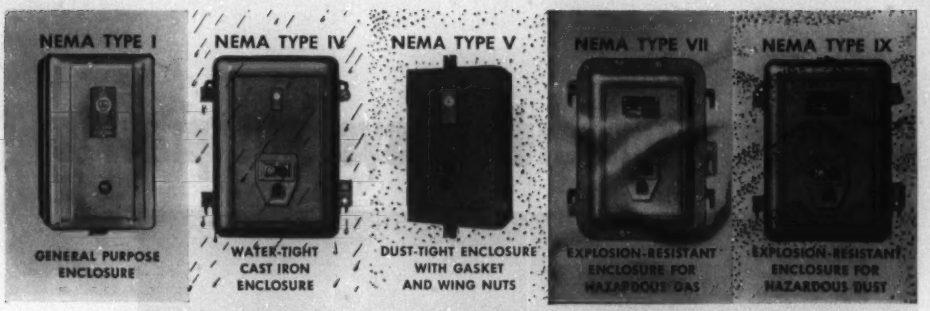

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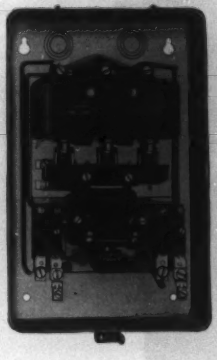

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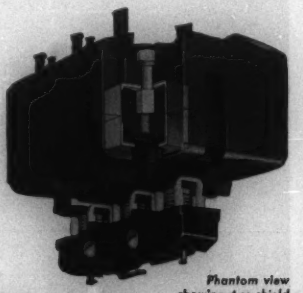

Phantom view showing Arc-shield

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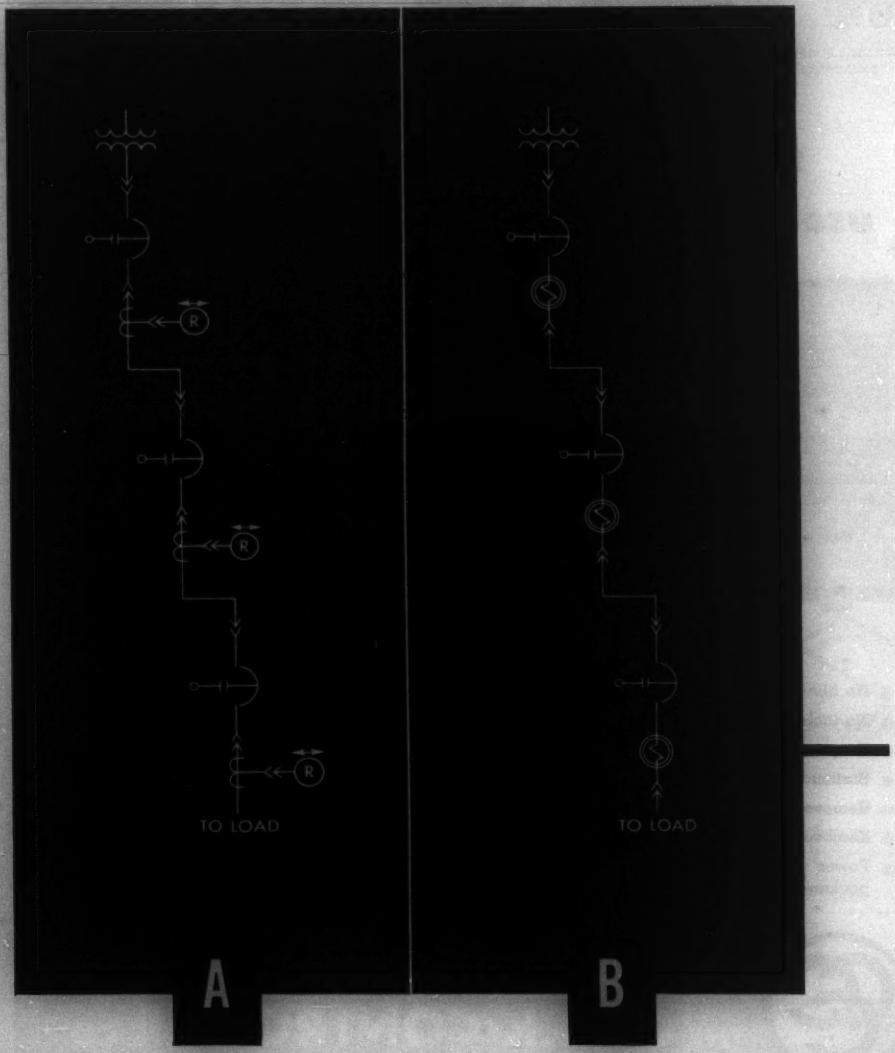

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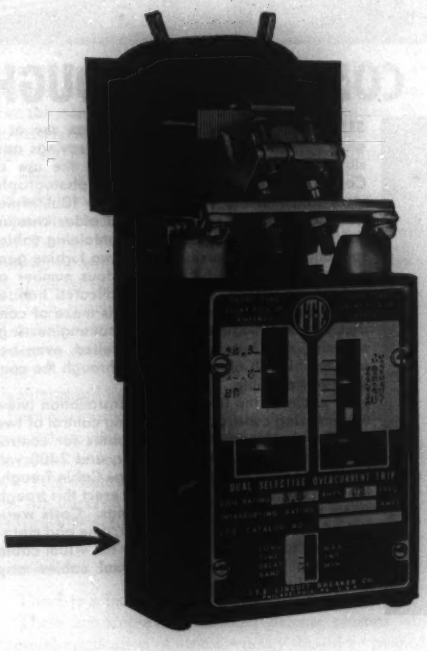

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Report to the Membership

D. A. QUARLES
PRESIDENT AIEE

The formation of an Atomic Industrial Forum, the resignation of Dr. Astin as Director of the National Bureau of Standards, and the latest development in plans for a new Engineering Societies Building are items of current interest to the membership discussed by President Quarles in this report.

ANNOUNCEMENT was made recently of the formation of Atomic Industrial Forum, Inc. This is an organization of individuals and industrial concerns interested in the application of atomic energy to civil uses, particularly for commercial power generation. The purpose of Atomic Industrial Forum as stated in its announcement is "to provide a forum in which industry might develop its best thinking in the interest of the advancement of the peacetime uses of atomic energy; a forum in which industry might develop an informed voice to be heard at government levels as new atomic energy policy is hammered out; a forum, not to serve the narrow interests of a few, but to stimulate the industrial development of atomic energy for the good of all."

With earlier public announcement that an atomic fuel power plant for submarines is moving out of the experimental and into the final design phase, and with a number of important industrial groups collaborating with the Atomic Energy Commission in actively considering the possibilities of atomic reactors as prime sources of energy for commercial power generation, the organization of the Forum is a timely move. While its area of activity is stated to be primarily the United States, similar moves are underway in other countries, particularly in Canada and England.

It is interesting in this connection that prominent people have been variously quoted in the press as predicting first commercial application of atomic power in the United States, some as soon as 2 years, others ranging up to 30 years. This disparity among the experts is a good indication of the uncertainties in the situation. Without trying to outguess the experts as to the timing, and their guesses provide a great deal of latitude, I believe there are some important items for engineers to note:

1. There is a lot of new technology to be mastered.
2. There are important national defense reasons why commercial application of atomic energy should be pushed.
3. The Government is increasingly favorable to such developments.
4. Electrical engineering is certainly one of the main ingredients.

There are factors such as security and the custody of fissionable materials that create pressure in the direction of Government ownership and operation of atomic power plants, a direction that all, I believe, including Government as well as industry, are agreed would not be best in the long run. Already one finds certain sections of the press raising an outcry about atomic power "grabs" much like the water power discussion some years ago. This point of view, which at times smacks of demagoguery, must be faced squarely, and the situation requires broad-gauged and well-informed statesmanship both in Washington and in the industry. There is no question but that atomic energy offers the long-range possibility of serving the common welfare and enriching the nation as a whole. There is no reason why these objectives cannot be achieved within the framework of our present free enterprise system.

One might compare this situation with that presented by air mail 20 or 30 years ago. It seems to me there is a close parallel. Initially the cost of the air mail service exceeded the revenue that could be realized from reasonable rates. There was, however, a strong national interest in nurturing the air transport industry as a basic element of defense. These somewhat conflicting considerations were reconciled in a national policy which in effect subsidized air mail, but did so without destroying the private initiative of the air lines. As a result valuable service is now rendered at a moderate price (even taking into account the concealed subsidy). The free enterprise system has been preserved and the common welfare has been served. These same principles can be applied in working out a national policy on atomic power. Under such a policy there is no question of a "grab." There is, however, the problem of getting the public to understand the situation and there are many questions for engineers and for industrial leaders, which are all the more challenging because not only public convenience, but public defense are involved.

Under these circumstances we in AIEE may take satisfaction in the quality of the leadership that has taken the initiative in organizing the Atomic Industrial Forum. We might note also that the AIEE has a technical committee structure which covers the atomic energy field.

THE ASTIN INCIDENT

BECAUSE of its somewhat remote connection with the AIEE, I think a brief report is in order on the recent incident in the Department of Commerce leading to the resignation of Dr. Allen Astin as the Director of the Bureau of Standards. The public in general, and engineers and

Excerpts from an address presented at the general session at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953.

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scientists in particular, have shown a keen interest in the circumstances of Dr. Astin's resignation. Some of you doubtless saw statements in the press quoting Mr. Sinclair Weeks, Secretary of Commerce, to the effect that he would convene a committee of prominent engineers and scientists to undertake an examination of the organization and functions of the Bureau, and stating that AIEE and other engineering and scientific bodies would be asked to name a representative to this committee.

I assume a general familiarity with the background picture involving unfavorable reports by the Bureau on a battery additive sold by a certain small business in California. These reports were disputed not only by the vendor but later, on his behalf, by members of the Congress. The transcript of the recent hearings before the Senate Small Business Committee is illuminating in this connection. While Dr. Astin was not heard by the committee, it was stated by Secretary Weeks that Dr. Astin's resignation was requested because of his handling of the battery additive matter, and for other reasons the Department at that time declined to disclose. In submitting his resignation Dr. Astin asserted that the Bureau's tests were conducted competently and, in fact, were repeated in order to check its findings. He implied that the results had to speak for themselves.

D. A. Quarles

Without prejudice to the technical merits of the case, it is fair to say that considerable resentment has been voiced (and some of it has been voiced to me) by those who feel that it should not be necessary for the director of a laboratory to consider the political expediency as well as the technical accuracy and adequacy of reports issued by his laboratory. People who view the matter in this way have been anxious that AIEE not lend itself to any device designed to justify the actions leading to Dr. Astin's resignation.

The part AIEE has played and is playing is as follows: On April 3 I received a telegram from Mr. Weeks stating that the National Academy of Sciences acting on his request had appointed Dr. M. J. Kelly, President of Bell Telephone Laboratories, chairman of a committee "to evaluate the present functions and operations of the Bureau of Standards in relation to the present national needs," and asking me to nominate a representative of AIEE to serve, along with representatives of a number of other technical and scientific societies, on this committee. A reply was requested as soon as possible in order that "this study be made at the earliest possible time." After learning from Dr. Kelly that the Astin matter was excluded from the terms of reference of his committee, and after checking with the AIEE Executive Committee by telephone, I prevailed upon Dr. C. Guy Suits, vice-president in charge of research of the General Electric Company, who had served on an earlier Bureau of Standards examining committee, to accept our appointment. My telegram of April 8, 1953, to Secretary Weeks nominating Dr. Suits stated my understanding that the Astin matter was excluded from the terms of reference of this committee. Mr. Weeks' reply of April 10 thanked me for the appointment of Dr. Suits and stated "the Astin matter is excluded from the terms of reference of this committee."

It has been my feeling throughout, and I found it to be the feeling of the Executive Committee, that the AIEE could not fail to respond to the call of a responsible government official for technical assistance, but that we should avoid political entanglements in the process. While I am sure many of us would like to see a competent group examine and clarify the whole Astin matter, it would be very difficult to keep such an examination on a strictly objective plane. In any event, this is not the assignment of the present committee, and from my conversations with Dr. Kelly and Dr. Suits I am satisfied that they will hold the committee on a straight and narrow path of scientific objectivity. As a final safeguard, if one is needed, Dr. Kelly tells me that it has been agreed that the committee's report will be published.

In a later communication Secretary Weeks has announced that acting on the advice of Dr. Kelly and others he has prevailed on Dr. Astin to continue as Director of the Bureau of Standards until next fall and until the committee has made its report. The Secretary went on to say that he holds Dr. Astin in high regard and that he will be offered another equivalent Government position when he is through at the Bureau. Dr. Astin has announced that he has agreed to stay on at the Bureau during the investigation.

Different groups have sent protests to President Eisenhower and Secretary Weeks, and the AIEE has been invited to join in these protests. Believing that it is best to let present actions take their course, we have not done so.

NEW ENGINEERING SOCIETIES BUILDING

THE INSTITUTE has received from United Engineering Trustees (UET) a definite proposal on planning for a new Headquarters Building which was considered at the Board Meeting on April 23. There has been so much interest in this matter that I shall outline the plan even though it is in the proposal stage. I am sure that the Directors would welcome any views that members may have on the subject.

Stated very briefly, the plan would be to sell the present building, and to buy a plot of land and erect on it a new building suitable for housing not only the present Founder

Societies, but any other professional engineering societies that might elect to join in the plan. It is estimated that around $6,500,000 would be required, more or less depending on the number of societies to be accommodated. Toward this cost UET would be in a position to make available some $2,000,000 from the proceeds of the sale of the present building and from depreciation and other reserves that have been built up over the years. Each of the Founder Societies is considered to have a one-fourth interest in these funds. It is expected that at least some of the societies to be accommodated in the building will have available their own reserve or building funds that might be added to the UET fund. AIEE already has indicated that it could make $300,000 available from its reserves for this purpose. The American Society of Civil Engineers has made a similar move and other societies are currently considering the matter. Each society would be considered to have an equity in the new building equal to its total contribution. AIEE's equity, assuming the foregoing figures, thus would be one-fourth of $2,000,000 plus its contribution of $300,000, or a total of $800,000. The gap between what might be made available through these reserves and the total cost of the building will have to be bridged by contributions or by mortgage. Optimistically, we might make up the whole difference by special contributions. Even if no contributions beyond the reserve funds were received we are advised that it would be possible to secure a mortage covering the balance and under favorable terms. As to location, a legal question has arisen as to whether, under the terms of the original Carnegie gift, the proceeds from the sale of the present building could be used for the erection of a building outside of New York City. While such a ruling would place other cities at a disadvantage in comparison with New York City, it is, I understand, still the view of UET that they are open to propositions from any other cities that wish to submit them.

Under the new building plan AIEE would have adequate space to meet its needs thus eliminating the present unsatisfactory arrangement which locates part of our work in rented space outside of the Headquarters Building. The plan would involve, however, a substantial increase in present rental charges, the amount of such increase depending somewhat upon the extent to which the building costs are covered by contributions rather than by mortgage.

It is our understanding that if UET receives broad endorsement of its present proposal, and all of the Founder Societies, of course, were represented in the formulation of the proposal, it intends to proceed aggressively with the plan. Without anticipating the action of the AIEE Board of Directors,* I think that we can say that it is heartening to see this matter take such a definite and promising turn.

EJC ACTIVITIES

In the area of Engineers Joint Council (EJC) activities there are some matters that I will single out for mention. Following up on the constitutional changes of EJC that became effective just at the end of last year, several other engineering societies were invited to join EJC and three have now accepted, increasing the original five to a present eight. Action by several others is pending. We believe that this is a very wholesome move, particularly as there are today so many matters of common concern to the engineering profession as a whole prominently before us, such as engineering manpower, revision of the Taft-Hartley Labor Relations Act, a new Engineering Headquarters Building, and last but not least, professional unity, to mention but a few. While we can take satisfaction in the EJC moves that have been made, these are weak first steps in the direction of professional unity, and I am sure the AIEE representatives on EJC realize that the Institute looks to them to keep pressing for more effective unity measures.

The Engineering Manpower Commission is continuing its active work under the chairmanship of Mr. Chilton with many interesting projects under way. Also, an EJC special committee on labor legislation has presented a statement to the Congressional Committees dealing with revisions of the Taft-Hartley Act, strongly supporting the provisions of the present Act which guarantee freedom of choice to engineering employee groups. These provisions of the present Act were achieved by united engineering society action, organized by EJC at the time of the Taft-Hartley Act. They are the engineers' Magna Carta and it is of paramount importance that they be preserved.

* *Editor's Note:* The AIEE Board of Directors on April 23 gave substantial endorsement to the UET proposal.

Time Compressor

A "time compressor" has been invented at the University of Illinois. It speeds up words or music without changing tone or ease of understanding. An hour easily can be compressed to 45 minutes.

The machine chops words or music into little sections, throws part of these away, and shoves the rest close together. Compressions of 10 per cent cannot be noticed, while more than 50 per cent of the time can be discarded without destroying understandability.

Scientists have known that words can be understood more rapidly than they can be spoken. Attempts at talking fast fail because the speaker slurs or trips over his words. The invention overcomes this by recording speech in condensed form without changing the pitch as happens when an ordinary recording is speeded up.

The device can stretch time and also change frequency or pitch to a narrow range without affecting time. The message can be transmitted and then expanded back to its original frequency range at the receiving end. This means that in the frequency width offered by a wire or radio channel now carrying one message, several may be carried.

The heart of the device is a revolving drum carrying 4 magnetic tape pickup heads. An endless loop of tape passes around it and over erasing and recording heads. Speed of drum and of tape can be adjusted independently to vary the amount of compression or expansion.

Safety Regulations and How They Affect the Electrical Industry

L. D. PRICE
FELLOW AIEE

Although the electrical industry recognizes the necessity for reasonable safety standards and regulations to minimize potential hazards to the public in the use of electric energy, care should be taken to avoid unnecessarily restrictive or loosely written regulations. Members of the Institute can help by advocating to local authorities the acceptance of nationally recognized codes and standards in local laws and ordinances which regulate installation and use of electric energy.

THIS IS A SUBJECT of such breadth that it is only possible to outline the basic problem, its effect on the electrical industry, and what members of the AIEE can do about it. However, because many members of the Institute are preoccupied by technical and administrative problems that are more pressing at the moment, they may not have an awareness of the serious effects that the problems involved in safety regulations have on the electrical industry. The effects are felt by the public at large, by members of the industry, by the companies or organizations with which you are associated, and by all segments of the electrical industry. Therefore, this article will attempt to focus a spotlight on safety regulations, as they apply to the field of supply and utilization of electric energy, and discuss the effect of these regulations on all of us associated with the electrical industry.

Perhaps safety regulations should be defined before proceeding further. For the purpose of this discussion, safety regulations will be considered as laws, ordinances, codes, or regulations, adopted at the state or municipal level in the interest of safety of the public, and which affect, directly or indirectly, the design, manufacture, sale, installation, use, or maintenance of electrical service and electric equipment.

THE PROBLEM OF SAFETY STANDARDS

IT IS IMPORTANT, throughout this discussion, to accept the fact that the electrical industry recognizes the necessity for reasonable safety standards to minimize potential hazards to the public in its use of electric energy. The National Electrical Code is tangible evidence of this recognition.

The regulatory state laws and municipal ordinances, together with codes or regulations which sometimes are made a part of such laws and ordinances, and sometimes issued under powers granted by the law and ordinance, affect the installation and maintenance of electric equipment in the form of electrical inspection, contractor and journeyman licensing, sales control, and regulations governing the use of specific types of equipment, such as welders, X-ray equipment, and so forth. They are based on the fundamental premise that electrical products should be so constructed, installed, and used that they, and their use, are reasonably free from fire and personal hazards. Unless the problems involved in the formulation of electrical safety regulations are considered from a reasonable, practical, nation-wide, and industry-wide viewpoint, local misconception as to how best to achieve safety protection often results in overly restrictive legislation. If these local regulations are unduly restrictive, the basic objective of safety to the public may not be realized and, in addition, unnecessary installation and maintenance costs may be imposed on the user. Restrictive safety regulations erect barriers to the free growth of the use of electric energy throughout the country.

Undoubtedly, much of the improvement in the living standards of the public during the past 50 years has resulted from the growth in the use of electric energy, and it stands to reason that further growth will occur as this useful servant is made available more abundantly to more and more people. Unnecessarily restrictive safety regulations impede this growth, and in many cases, may lessen safety to the public.

ELECTRICAL INSPECTION LAWS AND ORDINANCES

MUNICIPAL ORDINANCES AND state laws providing for inspection of electric installations generally are recognized and accepted as desirable for the purpose of providing a practical safeguarding of the public from electrical hazards to persons and property. In order to fulfill this purpose, the ordinance, in addition to providing for proper administration, should require that electric installations shall be in conformity with suitable standards developed to safeguard persons and property. The National Electrical Code, an American Standard sponsored by the National Fire Protection Association, and developed through democratic procedures by informed representatives of all branches of the electrical industry, including the AIEE, provides these standards. Similarly, the listings of Underwriters' Laboratories, Inc., a nonprofit testing organization, indicate conformity of electric equipment with established standards for safety of such equipment.

The behavior of electricity is not affected by city or state boundaries. Consequently, these standards may be specified and applied uniformly throughout the country with a uniform regard for safety. For example, the boundaries of

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many suburban municipalities are streets, and one not thoroughly acquainted with the boundary lines does not know whether he is in one town or the other. In some cases, restrictive electrical inspection ordinances or codes prohibit, or unduly restrict, the use of certain wiring materials and methods recognized by the National Electrical Code, thereby creating a situation where all recognized materials and methods are permitted on one side of the street and only a limited number of wiring materials and methods of installation are permitted on the other. As a matter of fact, the prohibition, by laws and ordinances or by rules issued under them, of the use of certain materials as recognized by the National Electrical Code has the effect of not only increasing unduly the cost of electric installations, but also of effectuating a form of boycott. More important, the effect of some of these unnecessary restrictions has been to cause initial installations to be pared to the bone, with the result that later additions to the wiring system are made, using unapproved, temporary methods, with a consequent increase in hazards.

Adherence to the requirements of the National Electrical Code, and the acceptance of the listings of Underwriter's Laboratories, Inc., not only assures the public of reasonable safety in its use of electric energy, but affords the public a free choice of materials and methods which may be used in their electric installations.

Emphasis should be placed particularly on this distinction between legislation for safety and the free choice by the users of electric materials and equipment. Just as a person should be free to choose between a Lincoln and a Ford automobile, so should a person be free to choose the wiring materials or equipment which he may desire for his electric installation. The only restriction that logically should be imposed by law is that the choice be confined to materials, methods, or equipment conforming to nationally recognized safety standards. In other words, reasonable safety standards may be given the force of law by legislative action; features in addition to reasonable requirements of safety, such as adequacy, provision for future expansion, and quality, should be promoted and sold on the basis of fair competition and in accordance with the American system of free enterprise.

CONTRACTOR AND JOURNEYMAN LICENSING

LICENSING OF ELECTRICAL contractors and electricians is, in general, inherently restrictive and is too often conceived and administered with the objective of limitation of free enterprise. Such legislation is contrary, therefore, to the best interests of the public. License fees must be reflected in the costs of electric installations in homes, factories, stores, and all building construction without necessarily increasing the quality or safety of installations. Excessive fees, unreasonable examination requirements, and other similar features of these industry restrictive measures create barriers to free enterprise and obviously result in increased electric installation costs to industry, commerce, and the public, generally.

From a safety point of view, proper inspection can accomplish the objective more effectively, efficiently, and fairly than can licensing. Inspection is made before electric installations are energized; therefore, improper installations, poor workmanship, and violations of the National Electrical Code provisions can be corrected as a result of inspection, with no resulting hazard.

SALES CONTROL LAWS AND ORDINANCES

ORDINANCES AND LAWS KNOWN as sales control or unsafe appliance ordinances are designed to establish control over the retail sale of materials to persons having little or no knowledge of electrical matters who attempt to do their own wiring, or over appliances which can be placed in service by plugging into an existing wiring system. Such ordinances should be limited specifically in scope of application to retail sales to the public, so as not to include industrial equipment.

Experience has demonstrated that the inclusion of industrial and commercial equipment is unnecessary and undesirable, because both the equipment design and the installation are engineered, the installations are made by qualified persons and are inspected, and the installations are maintained by competent personnel. Furthermore, such laws and ordinances should not be applied to regulate competition. Therefore, approvals should be based upon conformity with a single set of national standards and determined by corresponding nationally recognized methods of test. Such standards are available in the standards of Underwriters' Laboratories, Inc., and tests and certification are carried on by Underwriters' Laboratories, Inc.

It is the objective of some such legislation to establish laboratories or to utilize governmental laboratories, or laboratory facilities of local institutions, to certify conformance of electric equipment with local equipment standards. Such requirements, establishing a multiplicity of testing agencies testing to different standards, or using different methods of test, would be apt to lessen the degree of safety now realized, would bring about an impracticable situation in the distribution and sale of electric equipment and appliances, which would destroy, in large measure, mass production and add substantially to costs of marketing such electrical goods.

Loosely written ordinances may result in unnecessary and costly local approval procedures for industrial electric equipment, as well as appliances. Such a case occurred recently in one of our larger cities. There, a new administration officer interpreted the local ordinance in its broadest sense and prohibited the sale and installation of many nationally known industrial equipments, built to conform to nationally recognized standards. The resulting controversy has been resolved since through a reasonable revision of the ordinance, but the case illustrates the necessity for watching the development of such laws and ordinances very carefully.

Standards covering the design, construction, and operation of electric equipments, which lie beyond the normal scope of activities of Underwriters' Laboratories, Inc., are developed by nationally recognized standardizing bodies, such as the AIEE, American Standards Association, Inc., National Electrical Manufacturers Association, and many others. These standards, relating to electrical products, contain safety provisions in the form of specified clearances,

dielectric strength provisions, operating temperature limitations, and others. The electrical industry, as a whole, recognizes the necessity for the safe operation of electric equipment; therefore, these standards are applied broadly and voluntarily in the design, manufacture, installation, and utilization of these products and materials.

REGULATIONS AFFECTING THE USE OF SPECIAL EQUIPMENT

STATE LAWS, MUNICIPAL ORDINANCES, and regulations of governmental commissions sometimes include restrictions on the installation and use of industrial equipment, such as welders, industrial X-ray equipment, induction or dielectric heating equipment, and other miscellaneous equipment, which may result, through their misuse, in industrial hazards, influence communication facilities, or otherwise be construed to affect the public welfare. Such laws, ordinances, and regulations should be reasonable and not unnecessarily restrictive.

APPLICATION OF NATIONALLY RECOGNIZED STANDARDS TO SAFETY REGULATIONS

MANY OF YOU HAVE devoted many hours of arduous work, in co-operation with other informed representatives of the electrical industry, in the development of nationally recognized industry and safety standards. Prominent among these standards is the National Electrical Code. It is applicable wherever electrical safety installation standards are needed. The electrical industry leads all other industries in the development of this comprehensive, national safety standard. It would appear that, having such a standard available for use, local authorities would seize the outstanding opportunity to utilize it effectively. But what happens?

The National Electrical Code, and other nationally recognized codes and standards are used by the local government, to be sure, but in some cases only as a starting point—a steppingstone for the creation of a monument to local creativeness.

The local authorities take the standards as a basis for local regulations but start tinkering with them. The pet ideas and private dislike for certain types of materials, on the part of those in authority, are written in. Pressure groups of all kinds attempt to mold the regulations so as to improve their positions. Local committees are set up and although these frequently include professional people, they generally do not have a specialized experience with safety matters and may be unfamiliar with the preparation of standards. The result is that such committees may, in good faith, emasculate the standards in the course of preparing local regulations.

At times, when ordinances are written, portions of the standards are copied without any intent to change the meaning, but are given some presumably purely editorial revision which inadvertently twists the entire sense.

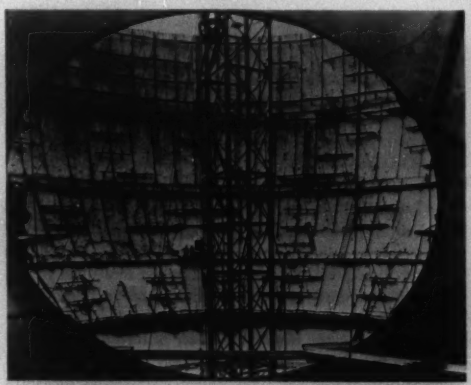
Moreover, when one city adopts a new safety ordinance, other surrounding localities frequently follow suit, and any bad features are copied along with the rest, thus multiplying the undesirable effect. Sometimes even typographical errors are thus copied.

All these forces combine to upset the effect contemplated in the preparation of the national standards. Even if, by some happy chance, a local code different from the national standard will achieve equal safety, the simple fact of such differences tends to defeat the economy and efficiency that are possible through the use of a single universal standard.

HOW THESE REGULATIONS AFFECT THE ELECTRICAL INDUSTRY

WE ARE ALL A PART of the electrical industry, whether as individuals, as companies, or as organizations, and no matter with what phase of the electric power supply and utilization industry we may be associated, we are all tied inextricably with the cash register of the industry—the watt-hour meter. The more meters that are in service and the faster the disks rotate in response to greater demands for electric energy, the greater the prosperity of the industry as a whole. And the industry cannot prosper unless the supply, installation, and utilization of electric energy provide reasonable safety to the public, in addition to its other virtues. It is only through the alertness of all of us connected with the electrical industry to the pulse of the local administrative authority that these unnecessarily restrictive safety regulations may be avoided. As recognized authorities in the field, members of the Institute can aid materially in the solution of this problem by advocating to local authorities, having jurisdiction, acceptance by them of nationally recognized codes and standards in local laws and ordinances which regulate the installation and use of electric energy.

Atomic Powerhouse



Large opening, resembling an eye, permits inside glimpse of gigantic steel sphere, under construction near Schenectady, N. Y., which will house an atomic power plant for submarines. Circular hole is for airtight entrance lock. Opening for another lock is seen on opposite wall of sphere. Rising in middle of sphere is base of 400-foot tower, used for erecting huge, inch-thick steel plates which comprise sphere

Wheatstone Bridge for Admittance Determinations

H. P. SCHWAN
ASSOCIATE MEMBER AIEE

KARL SITTEL

A-C WHEATSTONE BRIDGES, which provide high accuracy for resistance determinations, have been described in the literature in the past. Little attention has been given to bridges which combine high absolute accuracy in reactance or capitance with accuracy in resistance. This is especially true for low frequencies, and is in part due to the difficulty to determine the reactance of conducting materials at low frequencies. Another reason is the unavailability of variable-resistance boxes whose distributed inductances and capacitances are sufficiently well known to eliminate their effect on the reactance to be measured.

A Wheatstone bridge has been built which permits resistance and capacitance determinations within the frequency range from 10 cycles to 200 kc. It is built around an equal ratio arm and provides an amplifier section which contains sufficient filtering elements to cut down noise level to less than 1/10th of a microvolt. The smallest bridge output voltage which can be detected, is about 0.03 microvolt. Its maximum sensitivity in resistance is about 10^{-6} per cent for a bridge input voltage of 1 volt. Its maximum sensitivity in capacitance is given by the product of resistive sensitivity and loss tangent. The bridge is able to permit absolute resistance determinations accurate to 0.1 per cent in the range from 10 ohms up to 100,000 ohms, and with reduced accuracy up to 10 megohms. Its capacitance range extends from 0 to 1,000 micromicrofarads, permitting readings exact within 0.1 per cent over most of its range and extends up to 10 microfarads with somewhat reduced absolute accuracy (maximum error 1 per cent).

A major problem in the development of the bridge was the calibration of the reactance of the variable-conductance box which is used in one arm of the bridge. This problem is important in view of the fact that not only static capacities exist, but also inductances, simulating negative capacities which can be quite large. Especially at low-resistance settings this inductive correction is large and in this case exceeds more than 1,000 micromicrofarads negative capacity for resistances near 10 ohms.

In possession of such a reactance calibration it is possible with this bridge to carry out reactance determinations of highly conducting materials either directly or by substitution technique. The reactance calibration of the box is based on a step-up principle which expresses finally the effective capacities for all dials and each dial setting as they appear at the output terminals of the box in terms of one single unknown capacity. Knowledge of this unknown is obtained from a comparison with one standard of known reactance and resistance. However, it was found that the unknown capacitance value was not independent from the conductivity of the standard. Measurements with five different standards prove it to change linearly with the conductance of the standard. This effect is caused by the small inductance which connects the conductance box with the bridge. The detailed theory, which resulted from the careful consideration of all inductances, not only inside, but also outside the box, proved to be finally in complete agreement with the experimental performance of the box.

The theory shows that the net change in the reactance of the conductance box which takes place when its dials are changed from zero can be expressed by a capacity:

$$C^B = \sum C\mu,\nu - L_e G^2 - 2L_e G_e G$$

where $\sum C\mu,\nu$ is the sum of all dial capacities as given by the calibration of the box, L_e the inductance of the lead which connects the conductance box with the bridge. G is the conductance setting of the box and G_e the residual conductance of the box when all its dials are set at zero (in this case 100 micromhos). The terms $L_e G^2$ and $2L_e G_e G$ are small compared with $\sum C\mu,\nu$ as long as G is not too large. Under these conditions the effective change in the capacitance of the box is a good approximation, identical with the algebraic sum of the changes in capacitance of all the dials whose settings have been changed from zero. However, the term $L_e G^2$ will not be negligible when G exceeds values of about 10,000 micromhos. By use of the results of this theory, the accuracy of the corrections can be brought to the same order of magnitude as the precision with which the bridge balance can be determined; to do this it is necessary to determine the various inductances in the bridge with an accuracy of better than 0.001 microhenry.

The calibration permits in principle to determine capacitances of samples of 10 ohms resistance exact within less than 10 micromicrofarads, and of sample resistances of 1,000 ohms within better than 0.1 micromicrofarad. The sensitivity of the bridge permits carrying out such determinations at low frequencies within the limits as given in the foregoing. Its present performance can be characterized by the fact that it permits, for example, inductance measurements exact within 0.0001 microhenry.

The reactance calibration of the bridge has been performed at various frequencies and was found to be frequency independent for all resistors greater than 100 ohms. A small dependence on frequency was observed in the range from 10 to 100 ohms. Its existence is due to frequency dependence of inductance (varying skin effect) as it appears in some low inductive connecting bars in the bridge.

The bridge is currently used for the study of the dielectric properties of biological material at low frequencies.

Digest of paper 53-127, "Wheatstone Bridge for Admittance Determinations of Highly Conducting Materials at Low Frequencies," recommended by the AIEE Committee on Electrical Techniques in Medicine and Biology and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, Volume 72, 1953.

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This work was carried out at the Aero Medical Equipment Laboratory, United States Naval Air Experimental Station, Philadelphia, Pa.

Trends in Detection and Measurement of Radioisotopes for Medical Purposes

J. W. HITCH

Radioisotopes in increasing quantities and varieties are available to the medical field where they are being used in radiation therapy, diagnosis, and research. To determine the movement of radioactive materials in the body, specialized equipment is necessary as well as newly devised techniques for its handling.

SINCE THE ADVENT of the nuclear reactor, radioisotopes have been made available to the field of medicine not only in greater quantities, but in greater varieties. Several radioisotopes are now coming into wide usage, such as Gold 198, Iodine 131, and Phosphorus 32 in radiation therapy; Sodium 24 and Iodine 131 in diagnosis; and Carbon 14, Potassium 40, Sulphur 35, Copper 64, and others in medical research.

It is commonly known that certain compounds containing phosphorus or iodine are selectively absorbed either by certain organs or by diseased tissue. If radioactive phosphorus or iodine is used, it is possible frequently to locate and determine the limits of a tumor with a suitable radiation detection instrument. If radioiodine in the form of potassium iodide is introduced into the blood stream, part of it will be removed by the thyroid gland. The more active the thyroid, the more rapidly and completely the process is accomplished. Also, sodium chloride labeled with Sodium 24 can be injected into the blood stream to study the movement of blood throughout the circulatory system.

To determine the movement of radiomaterials in the body with accuracy, it is necessary that specialized detection equipment be employed. It is therefore recognized that if the maximum benefits from radioisotopes are to be fully realized, the investigator should appreciate the advantage of proper instrumentation. For this reason, an effort has been made in this article to review the latest developments relative to successful techniques for medical applications, not only those presented in the literature, but also that information obtained from conferences with manufacturers and actual visitation with users of radioisotopes.

For the benefit of those unfamiliar with radiation measuring techniques it may be desirable to review briefly the various types of detectors and to indicate why certain types are selected for specific applications. We shall consider only the detection of beta and gamma radiation which is characteristic of those isotopes currently being used in medicine.

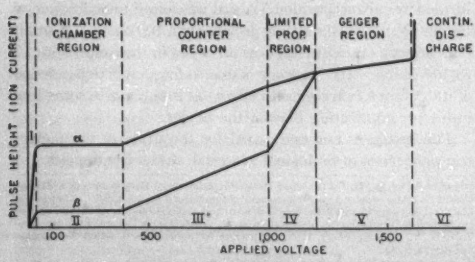

Figure 1. This graph illustrates how ion current increases with applied voltage between two electrodes in a tube filled with ionizable gas

ION COLLECTION IN AN ELECTRIC FIELD

ALPHA PARTICLES produce thousands of ion-pairs per centimeter in traveling through ordinary air, while beta particles of similar energy produce only a few hundred per centimeter. Gamma rays and similar electromagnetic radiations, such as X rays, are also capable of producing ionization in gases but do so indirectly. They cause electrons to be ejected from atoms of molecules in the gas or in other substances they may encounter. These secondary electrons produce the ion-pairs that make it possible to detect electromagnetic radiations.

If a sufficient voltage is applied to a pair of electrodes surrounded by an ionizable gas and an alpha particle or beta particle (or, in fact, any ionizing particle) is permitted to enter the chamber, each of the ions produced from the ion-pairs will travel toward the electrode of the opposite sign. As a result, a charge will collect on the electrodes and the meter will indicate a current. This voltage region, designated as *II* in Figure 1, is commonly known as the "ionization chamber region."* If the applied voltage is increased, the ion current is found to remain relatively constant. This plateau continues until a voltage is reached at which the initial ions will produce secondary electrons. The result is that more ions are now reaching the electrodes than were present in the original ionizing event and the charge now collected is no longer independent of the voltage. If the applied voltage is increased further, more and more secondary ions are created and the curve of ion current increases with the voltage. This voltage

* If the applied voltage is less than this minimum, as shown in Region *I* of Figure 1, the ion-pairs recombine and no charge is collected on the electrodes.

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range, Region *III* in Figure 1, is referred to as the "proportional region." It is noted that the slope of the curves due to alpha radiation and that due to beta radiation is the same. The two curves are displaced in the vertical direction because of the different number of primary ions formed by the different types of radiation throughout Region *III*.

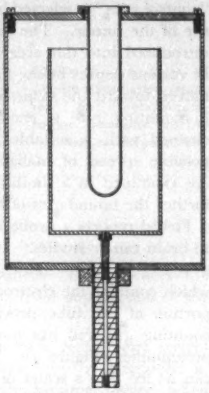

Figure 2. Diagram of the Braestrup chamber for 4-pi sample counting and which operates in the ionization region

It would appear that if the voltage is further increased, this process of secondary ion production caused by the acceleration of ions toward the collecting electrode would continue to increase the charge or pulse size indefinitely. However, since the central electrode is positively charged, negative ions are swept out of the collecting gas leaving behind positively charged ions. These ions give rise to what is known as a "space-charge effect," and the resulting positive ion sheath has the additional effect of apparently increasing the diameter of the central electrode and reducing the electrostatic field intensity in the counter tube. These factors limit the number of ions which may be collected at the electrodes. As a result of this phenomenon, the multiplication of secondary ionization cannot continue to increase indefinitely as the applied voltage is increased.

The region where the proportionality diminishes between the ion currents collected for alpha and for beta radiation at a given voltage is known as the region of "limited proportionality" and is designated as the Region *IV* in Figure 1. As the voltage is further increased it is found that the charge collected (or the pulse produced) depends no longer on the type of radiation causing the primary ions but only on the voltage applied to the electrodes. This region designated as *V* in Figure 1 is known as the "Geiger region." If the applied voltage is increased further, a point will be reached at which the tube discharges continuously. Operation in this region (*VI*) should be avoided because the counting tube may be damaged if this happens repeatedly.

METHODS OF RADIATION DETECTION

Ionization Chambers. The ionization chamber is one of the earliest devices used for measuring radioactivity. It was employed by Madame Curie, prior to the turn of the century, in some of the earliest studies of radioactivity.

In a broad sense, the term ionization chamber may be used to include all counters operating on the basic principle of measuring the ionization current produced when an ionizing particle enters an electric field. However, for reasons of convenience one usually limits the term ionization chamber to include only those instruments operating in Region *II* of Figure 1. Although they are very simple and convenient for measuring radioactivity, ionization chambers have the disadvantage of being able to produce only a very small pulse, thus making it necessary to employ very sensitive electrometer circuits. For this reason, they are used less frequently in diagnostic and therapeutic work than either the Geiger or proportional counters.

The Braestrup chamber, Figure 2, an ionization chamber for 4-pi sample counting and designed by C. R. Braestrup of the New York City Hospitals, is a good example of a measuring device operating in the ionization region. This chamber is now in wide use in both physical and medical research.

Proportional Counters. It can be seen from Figure 1 that if the applied voltage is increased above a certain value, the pulse size is no longer constant but increases with the voltage. The pulse condition is now represented by Region *III*, known as the proportional region. Proportional counters usually are constructed in the form of a cylindrical chamber which acts as a cathode and a central wire acting as an anode (see Figure 3). If the voltage gradient across these electrodes is sufficiently high, the electrons produced in the gases by an alpha or beta particle will move toward the central wire at a very high speed. In Region *III* this speed becomes great enough for the electrons to cause the ionization of other atoms and molecules in the gas.

This multiplication effect serves to produce an enormous pulse compared with that produced in Region *II*. If the voltage remains steady, the multiplication factor is constant and the size of the pulse produced is proportional to the number of ion-pairs produced by the original ionizing particle. For this reason, proportional counters possess the distinct advantage of being able selectively to detect one type of radiation in the presence of other types. However, in routine clinical work it has limited use, since discriminatory counting is not usually essential.

Geiger Counters. Geiger counters have been more widely used in clinical work than either ionization chambers or proportional counters. The counter tube in Figure 3 also may be operated in the Geiger region. When so operated, it is connected with a device capable of indicating only relatively large pulses, but not small ones. Thus the counting rate, through this range, is essentially independent of the applied voltage.

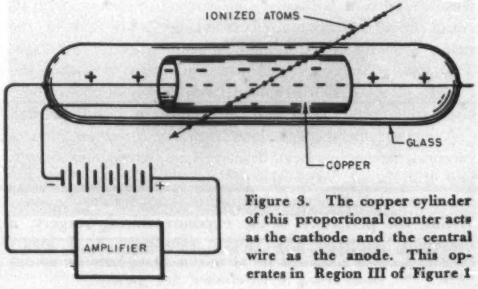

Figure 3. The copper cylinder of this proportional counter acts as the cathode and the central wire as the anode. This operates in Region III of Figure 1

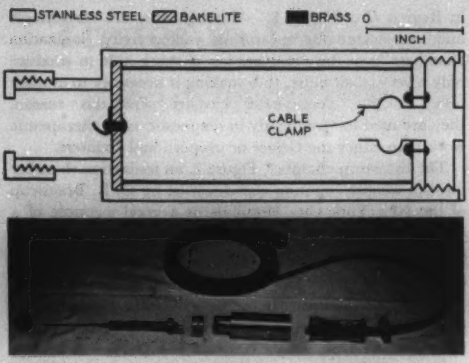

Figure 4. Exploded view and diagram of a probe counter which is used for studying brain tumors

Geiger counters have an advantage over ionization chambers and proportional counters in that the large pulses produced make it relatively simple to design electronic equipment which is reliable and easy to operate. The great variety of Geiger tubes and of possible shielding or collimating arrangements permits the measurement of localized activity as in the thyroid or within tumors. Needle-type Geiger counters may be used for probing in wounds for radioactivity or for pin-pointing the activity as an aid during brain tumor surgery.

Specialized Applications of Geiger Counters. Because the wide variety of counters which have been successfully used for thyroid-uptake measurements are well known, this discussion will deal primarily with more specialized techniques.

Boyack, Moore, Clausen, and Marvin,[1] in reporting experiments with radioactive diiodofluorescein employed as a tracer, used a collimated end-window Geiger-Mueller counter to detect the radiation from the Iodine 131 incorporated in diiodofluorescein. It was found that the dye tended to localize in the tumor tissue in concentrations as high as 17 times that in normal brain tissue.

A directional counting system employed by Weiland and Hahn[2] at the Meharry Medical College, consists essentially of two Geiger-Mueller counter tubes placed side by side in a lead housing. One tube is placed directly above an aperture and the other is completely enclosed. The second tube is used to detect the background with its count being subtracted electronically from that of the first. Thus the net counting rate can be directly indicated. This system has been used with radiogold to outline the margin of the liver and spleen, with radiosodium in blood circulation studies, and with radioiodine in thyroid studies.

A method for accurate localization and demarcation of cerebral tumors has been described by Selverstone, Sweet, and Robinson.[3] After the approximate location* of the brain tumor, radioactive phosphorus is given intravenously. Within the periphery of the exposure during surgery, a "control area" is selected in the region least likely to be the site of the tumor. The sensitive volume of the counter is introduced into this area and the counting rate recorded at various depths below the surface. Then the counter is moved toward the suspected region until a sharp increase in counting rate is encountered. The counter is then cleaned with a suitable antiseptic in order to prevent possible spread of malignant cells, and successive areas are examined in a similar manner in order to demarcate further the boundaries of the tumor.

Fields[4] reports a probe counter which has been applied to brain tumor studies. It consists of a counter tube with a relatively large diameter and a long slender probe, which contains the electrodes for the counter. The larger portion of the tube provides additional volume for the counting gas and has mounted to it a cathode-follower preamplifier (Figure 4). The output of this preamplifier can be fed into a scaler or a suitable counting-rate meter. By use of the preamplifier, it is possible to increase the life of the counter considerably by operating it at the lower end of the Geiger plateau. The rate of expenditure of the quenching gas is therefore reduced and the life of the counter tube is extended appreciably. Needle-type Geiger counters have a tendency to produce spurious counts if precautions are not taken to prevent flexing of the needle, a condition not always easy to avoid if one must do probing. For this and other reasons probe counters have met with varying degrees of success for diagnosis in brain and body cavities studies.

Friedell, MacIntyre, and Krohmer of Lakeside Hospital, Western Reserve University, Cleveland, Ohio, report that for detecting small neoplasms, such as may occur in the eye and where Phosphorus 32 is used as a tracer element, a small end-window Geiger counter has proved quite successful.

Moore and Kohl at the University of Minnesota Medical School, Minneapolis, Minn., have designed a system of 18 bismuth-wall counters connected to a bank of eight scalers so that a quick pattern of the distribution of radioactivity

Figure 5. A system of 18 bismuth-wall counters connected to a bank of 8 scalers for obtaining a pattern of brain radioactivity

* The location of the exposure to be made of cerebral or cerebellar cortex is determined by neurologic examination and by electroencephalographic and ventriculographic data.

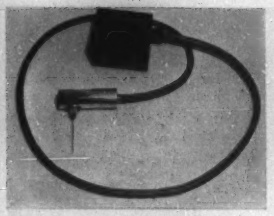

Figure 6. A type of needle scintillation counter for determining tumor locations during brain surgery

within the brain may be obtained. The counters are arranged so as to detect radiation from any portion of the cranial area (see Figure 5).

Photographic Detection. Photographic plates were instrumental in the discovery of radioactivity by Becquerel in 1896 when he noticed that they became fogged when exposed to certain elements now known to be radioactive. In recent years the improved composition of the emulsions used has made this method more suitable for the study of the various ionizing radiations. These emulsions have been used for certain applications, such as the detection and study of the radioactive materials in the thyroid[5]; or other portions of the body not too remote from the outer surface. However, their relative insensitiveness makes them unsuitable for tracer-level studies. Their chief advantage is their ability to present a graphic picture of the location and concentration of radioactive materials in histologic sections. Such autoradiograms are widely used in animal experiments.

Scintillation Counters. The development of the photomultiplier tube has brought a new type of counter to the field. The scintillation counter is a modern version of the old spinthariscope.* It utilizes the basic principle that when ionizing radiation is passed through certain types of crystals, it causes excitation in the crystal. This excitation is followed by the emission of light as the electrons fall back in their original orbits within the atom. The light is detected by a photoelectric cell or the photocathode of the phototube and the current thus obtained is multiplied in the multiplier section of the tube.

Many investigators who have designed scintillation counters for medical purposes feel that their high sensitivity to gamma radiation and their ability to detect radioactivity over a wide range of energy makes them preferable to the Geiger counter for many purposes. Most physicists who have used scintillation counters with favorable results seem to agree that reliable data cannot be obtained with a scintillation counter unless a linear amplifier and a very stable high-voltage supply are used.† For these reasons, it is questionable whether reliable data can be obtained with these scintillation counters unless more precise voltage regulation and amplification is incorporated than is usually available in most Geiger-counter systems.

Special Applications of Scintillation Counters. Kohl[7] recently described a needle-type scintillation counter for determining the exact location of tumors during brain surgery (Figure 6). The detector, employing an anthracene crystal and a *1P21* photomultiplier tube, was used to detect the radiations from Phosphorus 32 and Iodine 131. The needlelike probe is made from a duraluminum tube 3 millimeters in diameter with walls 0.1 millimeter thick, and 8 centimeters in length. The interior of the tube is highly polished and contains the phosphor and a small polished plastic rod for piping the light from the phosphor to the phototube. The disadvantage of spurious counts, caused by flexing of the needle in the probe-type Geiger counter, is eliminated.

A scintillation counter, designed by Kohl, Moore, and Chou,[8] has been found to yield an efficiency for the gamma radiation from Iodine 131 of 18 per cent as compared to 2 per cent for Geiger-Mueller counters. (The term efficiency is used to indicate the ratio of gammas detected to those passing through the sensitive volume.) Thus the higher efficiency of the scintillation counter appears to offer a distinct advantage over the Geiger-Mueller counter for tumor localization. The authors point out that when patients are suspected of having an intracranial lesion, isotope-encephalometric studies are performed routinely as the first diagnostic procedure. In 16 patients where the scintillation counter alone was used for the entire survey an accuracy of 100 per cent in diagnosis was realized; on the other hand, a collimated Geiger-Mueller counter showed an accuracy of 70 per cent. Accuracy was based upon confirmation of negative as well as positive tumor findings in subsequent surgery.

Several scintillation counters designed to detect the gamma radiation emitted by Iodine 131 have been built at the Atomic Energy Project at the University of California in Los Angeles. A recent report by Cassen, Curtis, Reed, and Libby[9] is noteworthy. This counter, according to the authors, can easily detect with 1/4-inch resolution the boundary of a region containing only 0.2 micro-

Figure 7. A scintillation counter with directional properties can be mounted in an automatic mechanical scanner for determining the boundaries of active tissue

* A spinthariscope is a device consisting of a small tube containing a mixture of zinc sulfide and radioactive salt on a screen at one end and a lens at the other end. It was used in early studies to observe scintillations from radioactive materials.

† A linear amplifier similar to the "Model A-1" designed and used at Oak Ridge National Laboratory. High-voltage regulation: less than 0.01 per cent change in output voltage for each per cent change in input voltage; from 105 to 125 volts at any output voltage setting.

curie of radioiodine per square centimeter. The instrument has been designed with a probe which can be held or mounted in an automatic mechanical scanner (Figure 7). If the instrument is held in the hand, one can make a rather rapid determination of the boundaries of the thyroid gland or other active tissue. The automatic scanner is used to give a graphic outline of the radioactive area within the patient (Figure 8).

A more recent article by Allen and Goodwin[10] describes a technique used at the Wadsworth General Hospital in Los Angeles. The system employs a scintillation counter for in vivo estimation of the thyroid size. A collimated detector and a manually operated scanner are mounted on the adjustable arm of an X-ray stand. The thyroid gland is outlined by using a system of rectangular coordinates on plastic as in Figure 9. After the survey is completed, the counts are transcribed from a strip-chart recorder to the plastic grid. The collimated or "directional" counter used in the system is reported to have a sensitivity 35 times that of a Geiger-Mueller counter.

Another scintillation counter in use at this institution is the "wide-angle" counter for measuring Iodine 131 uptake. This counter is reported to have a sensitivity 100 times that of a Geiger-Mueller counter. The higher sensitivity makes it possible to use very small quantities of Iodine 131, for example, 1 microcurie compared to 50 microcuries, or sometimes more, necessary when using Geiger-Mueller tubes for this purpose.

Wrenn, Good, and Handler[11] at Duke University, Durham, N. C., report a novel technique for localization of brain tumors. The opposed scintillation counters are operated in coincidence to detect and locate concentrations of Copper 64. This isotope has a decay scheme of 54 per cent K-capture, 31 per cent β-emission (0.571 million electron volt), and 15 per cent positron emission (0.657). The positron has a path of only a few millimeters in tissue and a strong point source of gamma radiation, given off in two opposite directions, results from the annihilation.

In the experiments reported, tetrasulfonated phthalocyanine was tagged with Copper 64. The preferential absorption of this anionic dye by the tumor provided a means of concentrating the positron emitter in the diseased tissue. By establishing lines between points where coincidence counting was the highest, it was possible to establish their common point of intersection, and thus indicate the location of the tumor.

Friedell, MacIntyre, and Krohmer of the Lakeside

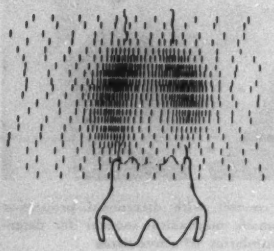

Figure 8. Graphic outline of radioactive area in patient's thyroid obtained with scintillation counter in scanner of Figure 7

Figure 9. A collimated detector in a manually operated scanner being used for outlining a thyroid gland

Hospital, Western Reserve University, Cleveland, Ohio, report efficiencies as high as 50 per cent for scintillation counting when using Iodine 131 in thyroid studies. In addition, successful results have been obtained with iodinated human serum albumen where the vascular flow and total cardiac output were to be measured. The sodium iodide crystals are reported to be 5 times more sensitive than anthracene for detecting the gamma radiation from Iodine 131. For studies on the back side of the eye where the use of a Geiger counter is not practicable, it is proposed to use a curved Lucite cone with a small anthracene crystal embedded in the Lucite at the apex. The base of the cone is sealed to the photomultiplier tube. To minimize counting time, a counting-rate computer is used to record with reasonable success the output of a scaler. This device electronically computes the counting rate and graphically records it on a strip-chart recorder.

Myers, Department of Medicine, Ohio State University, Columbus, Ohio, has also experienced favorable results using a scintillation counter. Comparisons have been made of the relative merits of bismuth-wall counters and conventional Geiger-Mueller counters for clinical purposes. It is reported that the bismuth counter is 3 times more sensitive to Iodine 131 than is the conventional counter, and that the scintillation counter is several times more sensitive than the bismuth-wall counter.

Feitelberg, Mount Sinai Hospital, New York, N. Y., has reported successful results with scintillation counters for in vivo counting, and for sample counting uses liquid phosphors* to provide 4-pi geometry. The volume of the phosphor material proves to be a limiting factor since considerable light is absorbed if the scintillations occur in the portion of the phosphor remote from the photomultiplier tube.

Bell, Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., has suggested that the accuracy in locating radioisotopes in biological systems can be im-

* Terphenyl mixed with diphenylhexatriene and phenylcyclohexane.

proved by using a scintillation spectrometer (Figure 10). Such devices would not necessarily be as complex as those used in physical research and possibly could be placed on the market at a cost comparable to that of a complete system for reliable scintillation counting. Scintillation spectrometers would have the advantage of being able to detect only that radiation which is characteristic of the isotope being used and would essentially eliminate counting of radiation due to backscatter.

SELECTION OF EQUIPMENT

Because of the desirability during diagnosis of keeping the amount of radioactivity to a minimum, measurements are preferably made at low levels of beta and gamma radiations. A highly efficient and dependable counter is therefore desirable.

The gamma efficiency of ordinary Geiger counter tubes has been much improved in recent years by the use of multiple baffles or high "atomic number" (bismuth cathode) walls in their construction. These counters, as do ordinary Geiger tubes, offer the advantage of simplicity of associated circuits compared to the types of circuitry necessary for dependable scintillation counting.

Where gamma-ray emitting radioisotopes are used in tracer quantities, the use of properly designed scintillation counters appears at the present state of the art to provide one method for reducing dosage size to a minimum without undue loss of detection. In addition, a more precise determination of the area of localization appears possible. Sodium-iodide (thallium activated) crystals used in scintillation counters have proved extremely efficient for gamma detection. However, the cost of these crystals together with the extensive circuitry required for reliable operation of the photomultiplier tube may result in the less efficient Geiger counters being preferred, unless specially trained personnel are available.

For the detection of beta-ray emitters, both Geiger and scintillation counters have proved to be equally efficient, but because the scintillation counter system will detect more efficiently any gamma radiation, it is winning a prominent position in the field. Several companies have designed systems especially adapted for clinical purposes, but at present, only a few offer complete systems designed for in vivo counting.

Specially designed 4-pi ionization chambers are being used successfully for in vitro measurements. Both liquid and solid phosphors capable of providing 4-pi geometry in scintillation counters have come into use recently. In addition, 4-pi Geiger counter tubes have been used also but results are somewhat inconclusive.

SUMMARY

For in vivo counting, collimated counters (either Geiger-Mueller or scintillation type) appear to be used very widely. A new development in this field is the introduction of automatic scanning devices that plot the outlines of localized concentrations of radioactivity, for example, of Iodine 131 in a thyroid gland.

Scintillation counters are being developed which promise reasonably satisfactory stability and troublefree operation.

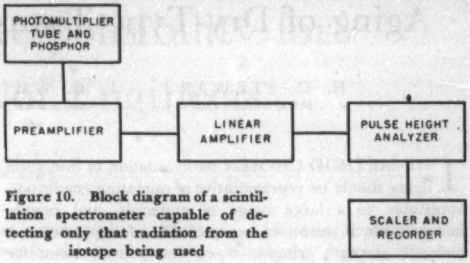

Figure 10. Block diagram of a scintillation spectrometer capable of detecting only that radiation from the isotope being used

Their increased sensitivity for gamma radiation, as compared to Geiger-Mueller counters (either with or without bismuth walls), appears to offer a distinct advantage where very low dosage levels of radioisotopes are required to prevent interference with the normal physiological function of an organ.

Needle- or probe-type counters for use in brain surgery have been devised using either a scintillation crystal or a conventional Geiger-Mueller tube as the detecting element. The scintillation counter requires that the light from the crystal be piped to the photomultiplier tube outside the surgical area. A preamplifier mounted either on or near the probe may be necessary. The Geiger-Mueller needle-type probe may also require a preamplifier and a fairly large reservoir of filling and quenching gas as integral part of the probe to extend the useful life of the counter.

Where beta counting only is involved, the scintillation counter appears to offer no particular advantage over the conventional Geiger-Mueller counter, but where both beta and gamma radiation are, or may be involved, scintillation counters offer considerable versatility in instrumentation. However, the need for high stability of line voltages for reliable scintillation counting is an important factor in selecting counting equipment.

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Aging of Dry-Type Transformer Insulating Systems

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THE METHOD CHOSEN for evaluation of insulation aging should be representative of operating conditions, applicable to a large range of materials, and readily interpretable in terms of expected life of apparatus. A dielectric strength criterion meets these requirements for dry-type insulating systems. In utilizing this criterion the initial strength of each insulation system is determined at the temperature being investigated. Duplicate samples of the insulating systems are then thermally aged at this temperature and periodic, 60-cycle, 1-minute dielectric strength tests are applied at a value of one-half of the initial hot-dielectric strength until failure occurs. Plotting the hours of thermal aging to reduce the dielectric strength to one-half of its initial value against the operating temperature for a range of temperatures gives the thermal aging characteristics for the insulating system.

Data are presented which show the effect of the gas mediums, air and nitrogen, on insulations with both organic and inorganic base materials and with silicone as well as phenolic resin impregnants. A summary of these aging characteristics is shown in Figure 1.

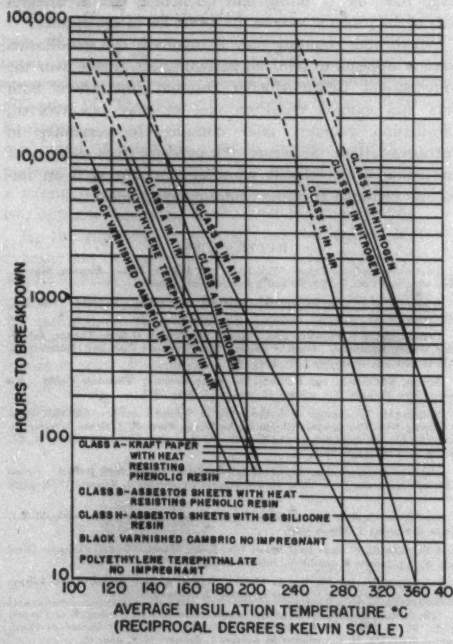
100,000
10,000
1000
100
10
HOURS TO BREAKDOWN
GLASS H IN NITROGEN
GLASS B IN NITROGEN
GLASS H IN AIR
GLASS B IN AIR
GLASS A IN AIR
GLASS A IN NITROGEN
POLYETHYLENE TEREPHTHALATE IN AIR
BLACK VARNISHED CAMBRIC IN AIR
CLASS A—KRAFT PAPER WITH HEAT RESISTING PHENOLIC RESIN
CLASS B—ASBESTOS SHEETS WITH HEAT RESISTING PHENOLIC RESIN
CLASS H—ASBESTOS SHEETS WITH GE SILICONE RESIN
BLACK VARNISHED CAMBRIC NO IMPREGNANT
POLYETHYLENE TEREPHTHALATE NO IMPREGNANT
100 120 140 160 180 200 240 280 320 360 400
AVERAGE INSULATION TEMPERATURE °C
(RECIPROCAL DEGREES KELVIN SCALE)

Figure 1. Summary of life characteristics of insulations in air and in nitrogen

Considering available materials, certain technical limitations, aging data, and experience and economics, the following two practical systems of dry-type transformers seem justified:

1. Open 140-degree-centigrade Unit—Ventilated Construction. The individual manufacturer would use class *B* or a combination of class *A* and class *B*, or other satisfactory materials which could be demonstrated by the test method outlined in this article to have a satisfactory life at 140 degrees centigrade.

2. Sealed 200-degree-centigrade Unit—Sealed-in Nitrogen Construction. The individual manufacturer would use class *B* or class *H*, or a combination of them, or other satisfactory materials, which could be demonstrated by test methods outlined in this article to have a satisfactory life at 200 degrees centigrade.

From considerations of ambient changes and usual transformer loading, the value of 20,000 hours may be used as an ordinate on Figure 1 for determining anticipated insulation temperature that will give normal transformer life.[1] Conclusions from this aging data are

1. Additional aging data substantiate the previous conclusion that operation of class *B* in air should be limited to 130-degree-centigrade hot-spot temperature averaged over 24 hours (140 degrees centigrade maximum).

2. New aging data on silicone insulations in air operated at 225 degrees centigrade maximum temperature show about the same aging characteristics as class *B* in air at 140 degrees centigrade maximum temperature.

3. New aging data on silicones (class *H*) in nitrogen show that for equal thermal aging, their temperature may be increased about 50 degrees centigrade over that of silicones operated in air (ventilated).

4. Additional aging data on class *B* insulation in nitrogen show that for equal thermal aging, its temperature may be increased by about 130 degrees centigrade over that of class *B* insulation operated in air (ventilated).

5. Class *B* insulating systems operating in nitrogen, when replaced with relative humidity air for as much as six 24-hour periods of exposure, show minor change in aging characteristics.

6. When operated in a gas atmosphere, such as nitrogen, the aging characteristics of class *B* and class *H* insulations are not significantly different and from this point of view there is little to choose between them.

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Management's Responsibility for Development of Engineers

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Every company's management plan must include a concrete program for the development of its employees. Any such plan for the progress of the engineering personnel, whether along the path of supervision and management or of technical achievement, should consider the development of the engineer's technical and organizational abilities, his professional society activities, and his relationship with society as a whole.

BROADLY, IT IS very true that management has responsibility for the development of engineers, but it is equally true that engineers are in general an integral part of management. Most obvious of all, professional people must carry at all times the principal responsibility for their own development. Nevertheless, professional management is defined as "the task of administration of a business enterprise through leadership of its personnel to achieve its objectives by planning, organizing, measuring, and integrating its human and material resources."[1] Implicit in this concept is the continued development of people so that they progressively can take increasing responsibility and produce contributions of steadily increasing worth. Every management plan, therefore, must have as one component a concrete program for the development of people. This article will consider the portion of a management plan which has to do with the development of engineers.

In general, it would seem that any plan for the development of engineers should provide for progress along four separate but interrelated lines:

1. Development of the technical ability of the engineer.
2. Development of the organizational ability of the engineer and of clear relationships between him and others in the organization.
3. Development of the professional society activities of the engineer.
4. Development of the engineer to exercise proper leadership in society at large.

DEVELOPMENT OF TECHNICAL ABILITY

Selection. First, consider the technical development of engineers. This is a subject to which the General Electric Company and many others have devoted a great deal of thought and attention over the years. Long before the start of this century the General Electric Company embarked on a practice of recruitment of young college graduates with engineering training as opposed to the more conventional plan of waiting for applicants. This program of recruiting brought with it both the responsibility and the possibility of improvement of the engineer through initial selection, training, education, and proper job assignment. In selecting an engineer for industrial employment, it must be recognized that a corporation is a highly civilized component of society if by civilization we mean one of its dictionary definitions: "the art of living together."

Therefore, probably the three outstanding criteria for selection are the distinctly technical attainments as shown by the college record, the professors' analyses of the individual's technical capacity, and a summation of those factors which indicate whether or not the particular individual is likely to be interested in, acceptable to, and therefore happy in an atmosphere of group endeavor. It might be asked why this has anything to do with technical development. The answer is that one of the great strengths of engineering activity in a company such as General Electric lies in the degree to which even the most brilliant individual workers co-operate with one another and can use the help of others to increase their own technical knowledge. It is the author's belief that the heights of technical attainment can be reached today only by a man who by nature can participate freely in give-and-take between at least equally gifted individuals. This point is stressed here as part of the development of technical ability only because it is quite apparent that this kind of ability is needed in many of the pursuits commonly chosen by engineers such as sales or professional management, but it may not be so obvious that it is equally needed for the highest technical attainment. In other words, no matter what the field of the prospective engineer, management's first responsibility is to recruit men who by nature as well as training can participate fully and effectively in corporate activity.

Training. It has been the concept at the author's company for many years that a definite training program is of the first order of importance the moment that the new employee reports for work. Such a training program is represented by what is commonly known as General Electric Test. Rather than assign a student engineer immediately to a given spot in a particular business, it has seemed wise for many years—and still seems wise today—first to explore his capabilities and at the same time to

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allow him to explore the opportunities in a company such as ours. The General Electric Test Program involves a series of rotational assignments in several locations and businesses. The work is intentionally quite varied. Assignments may range from direct work in an engineering office through developmental or experimental test to such activities as the direct testing of major equipment such as our largest turbines, motors, and locomotives. During this time emphasis is placed on four factors: First, it is our concept that every assignment should be such that the man feels a distinct sense of responsibility. Second, the man really should feel that he is producing. Third, every assignment should be such that a man can be and is measured not only on his technical grasp, but by his ability to get things done and to accept responsibility. Finally, each assignment should contribute an opportunity to see a separate phase of the varied work of our large company, thus giving the man as full as possible participation in his choice of future work.

In regard to the work assignment where the man actually begins his productive career, it has been a recognized principle that during this period education should be made broadly available recognizing, however, that engineers vary among themselves as do all human beings. General Electric for years has conducted what is known as a General Course. This is a preliminary orientation program partly concerned with the operation of the company and partly dealing with an introduction to the type of work encompassed in the company's engineering activity.

Specialized Education. Nearly 30 years ago, it was recognized that the company should go much further than this simple course, however, for those who appear interested in and capable of high technical attainment. What has come to be known as the General Electric Advanced Course or Advanced Engineering Program was instituted at that time under the initial direction of the late Dr. Robert E. Doherty. This Advanced Engineering Program consists of two phases. The first is a general analytical course. At the completion of this course, which occupies the first year, the student through lectures and experience with actual problems has been given familiarity with the basic tools used in attacking engineering problems in nearly any field. Obviously these tools are usually only an extension of the basic knowledge obtained in college. Nevertheless, experience has shown that the college education probably necessarily gives substantial attention to fundamentals but provides little opportunity for learning how to handle these fundamentals in the solution of practical problems. The first-year activity gives facility in this latter respect, and at the same time reviews the opportunities for the development of special skills beyond those learned in college.

In the second and third year of the program the student is encouraged to specialize. Some emphasis is given to the problem of making a student still more familiar with advanced technology in many fields. Principal emphasis, however, is towards specialization in engineering fields which meet two criteria: first, are not generally available by experience or association in a number of the company departments; and second, are considered likely to be of substantial importance in the future development of existing businesses or in making contributions to society in the shape of new businesses. Examples are the inauguration of a high-frequency course in 1929, and a course in the systems concept in 1930; also, of advanced study of heat transfer and fluid flow in 1932. These subjects, of course, today have widespread application throughout the company but at the time truly represented advanced thinking.

This basic Advanced Course was supplemented more recently by two other courses of approximately the same level: the first, introduced in 1937, is the Creative Engineering Program, and the second, in 1946, the Process Technology Program.

The Creative Engineering Program is directed towards the selection of individuals who have strongly creative possibilities and the development of these creative skills so that the individual will have more than the usual technical competence to guide his creative work, and at the same time will have developed confidence in his ability to obtain substantial and unusual solutions to difficult problems. The course in Process Technology recognizes the difference between the typical background required for those engaged in the development of materials and processes from that required by those who expect to engage in the development of devices or machines. The course thus is designed to give much the same level of training to the man whose background is in the material and process field.

These courses by no means comprise the whole list. There are an Advanced Manufacturing Training Program, Marketing Training, and many other functional training programs for those whose interests and abilities lie in these functional fields. These three simply illustrate the general principle—that is, it is felt that both the company and the individual will benefit by providing for the selected individual a unique opportunity in his first few years with the company to develop special technical skills and confidence in the application of these skills. One cardinal principle of these courses is that they are given on a participating basis. While engaged in the Advanced Course the men are doing productive engineering work in varied engineering assignments. In such assignments the men are on the payroll of the department in which they work. They cannot continue or complete the course unless they are doing work satisfactory to the business to which they are assigned. The company provides instruction, material, instructors, and so forth, and the student is paid during the classroom time of 4 hours per week as though he were on a regular assignment. The work is planned, however, so that approximately 20 hours per week of study and problem work must be put in by the student.

It is recognized that there are many special technical courses which can be obtained directly from established educational institutions, and hence the company provides plans whereby men can be encouraged with appropriate financial help to improve requisite technical skills by this means. Finally, many of our departments conduct high-level courses in specialties particularly applicable to their businesses. These, then, provide what we consider

management's responsibility for formalized technical education for the engineer although this by no means is the limit of management responsibility.

Placement. At the conclusion of the Test training program and subsequent educational programs, the young engineer and the company face an important milestone—that of initial assignment to what is usually a relatively permanent position. Here we encounter a rather interesting phenomenon. It is our considered judgment that by and large there is generally no single business in which a man is likely to be successful. Rather, a man is much more likely to succeed because of the nature of the activity in which he engages and the degree to which it holds and captures his interest, than the particular product involved or the particular growth rate of the business. This may be more apparent if we consider the case of an engineer who has worked on, say, large central station turbines for 10 years and another who has worked on household flatirons for the same period. Both probably have had substantially the same technical education, both have explored numerous fields in common subsequent to their college education; each has some knowledge, however, of his business which is particularly applicable to that business. Therefore, both men are likely to be similar except for a very small overlay of inapplicable experience obtained over a relatively short portion of their productive lives.

On the other hand, there is usually a wide divergence between a highly successful development engineer and a man whose success has lain along the lines of production engineering or the management of engineering work. The attributes which separate such men are the product of heredity, going back long before the man was born, and the total environment of the individual since birth. They are far deeper than a superficial overlay of experience. Therefore, in the initial stages of placement, management has a direct responsibility to see that men do not attempt to choose superficially. Engineers must attempt to analyze themselves for their own capabilities while at the same time management uses the most expert and up-to-date techniques in such analysis, the net desired result being to provide a man with substantial opportunity at the earliest possible date to follow the type of career in which he is most likely to succeed.

Furthermore, management has the responsibility to continue this process. Men inevitably will perform relative to each other along a statistical pattern. Management should provide a rating and individual analysis procedure which will serve as a guide both to the company and the individual to help in determining the individual's present and future progress. The company management should be continually reviewing its technical personnel with an eye to singling out those who show exceptional promise in any field of endeavor and then providing encouragement and help for the individual to increase his effectiveness. Conversely, of course, and equally important, is the analysis for reasons underlying lack of promise, and, if possible, corrective action for these reasons.

As a final step in the technical training program, management certainly has the responsibility to follow up from the results of its planned training and additional programs to determine as accurately as possible the extent to which these programs have helped the individual and through the individual have helped the company. It is easy to assume that selection and training are of value, but it is truly difficult to determine these factors quantitatively.

DEVELOPMENT OF ORGANIZATIONAL ABILITY

Supervision. The second point in a management plan for the development of engineers concerns the development of the engineer's organizational ability and relationships. This is a field in which knowledge and experience are accumulating rapidly but one in which our state of perfection is probably far behind that of technical training. It seems that the first and most important step in this process should be the selection of a young man's supervision. It is all too easy to assume that a young man should be thrown in with others to work out his lot and that the best man will rise to the top. It is the author's personal belief that this is statistically true, but the process can be greatly accelerated by the influence of good supervision. Much has been written on the art of supervision which, of course, cannot be recounted here, but the following four important factors can be noted:

First, the supervisor must know that he is a supervisor and has both authority and responsibility.

Second, the supervisor must have the human characteristics needed to inspire and therefore develop young men.

Third, the supervisor must be technically exacting so that his men learn to keep their thinking processes straight.

Fourth, the supervisor must be equally exacting in requiring that his men plan ahead rather than be content to do the day's work.

Much has been written and said on the subject of the supervisor. We must never forget that each engineer owes an obligation to his superior. The engineer, in making decisions, must put himself truly and objectively in the boss's shoes and try to see things as he sees them. It is a 2-way relationship—the boss must help his men to develop themselves, but he cannot do this unless they truly try to help him execute his responsibility as he sees it.

Individual Attainment. If the man chooses the path of individual technical attainment and seems likely to achieve pre-eminence, management must consider the extent to which he is backed up by appropriate facilities and experimental or developmental programs. If, on the other hand, the man's best path seems that of supervision and management, we are becoming increasingly aware that management itself is a science as well as an art, and it is our responsibility to make available to such men a good technical foundation on which to build their abilities and skills in this area. Courses in management are becoming increasingly available in educational institutions, in associations such as the American Management Association, and in industry itself. The selection of engineers for this training and the provision for such training are certainly responsibilities of top management.

Organizational Structure and Understanding. At this point

as well as throughout the engineer's career, management owes him a clear understanding of the function he is to perform and the manner in which his performance will be measured. Along with all other employees management owes the engineer a proper organizational structure in which to develop. For a more complete discussion of the subject, see T. M. Linville's article, "Management of Engineering Work,"[2] which contains a great deal of material on the development of a proper organization.

It is important, too, that the young engineer should be given an understanding of the organization in which he finds himself. Now this applies, of course, to any employee, but it is particularly true of engineers. By and large the engineer makes his greatest accomplishments by doing what has not been done before; in other words, by breaking established precedents and rules. The engineering mind is prone to take rules and patterns as a challenge to his ingenuity rather than as roads to be followed. Nevertheless, the engineer accepts scientific principles which his experience indicates are applicable. The important thing is that not only must the organization be sound, but that the engineer should comprehend quickly the nature of the organization in which he finds himself and the principles on which it is built; and that the engineer should be encouraged to use it as a tool for his own and his company's advancement rather than as a framework to circumvent by the application of his creative mind.

This is not to belittle the problem of expressing the principles of organization and the practice of management in a truly scientific manner. This can, and will, be done and the engineering approach will help in the process. To the extent that management clearly spells out the true principles of its own work, it can be assured that engineers will help in the process and co-operate toward the common goal.

Creative Drive. Management also owes the engineer a clear understanding of creative drive. This drive is compounded of two factors: dissatisfaction with the status quo, and satisfaction on the part of the individual that he can and should change it. This dissatisfaction may apply equally to parking privileges and accepted beliefs concerning the laws of nature, and the satisfaction of making changes may be almost equal in both fields.

That the creative urge requires inspiration as well as training and understanding cannot be overemphasized. Management must challenge the imagination of creative people. Engineering management must help to guide the technical effort of young engineers and scientists. However, this must be done in such a way that the men are continually and truly inspired to take on for themselves increasingly difficult objectives. In the course of such progress management must understand what the men are doing well enough to see that they keep on the right path while avoiding the danger of stifling their initiative.

Self-Development. In progress up through an organization the process of self-development must be continued with steadily increasing emphasis on the degree to which the man himself should take over. Nevertheless, management has very distinct responsibilities. An engineer or scientist very seldom can develop to his and his employer's maximum advantage without certain facilities at his disposal. While he must have the opportunity to experiment which requires that proper and sometimes very expensive facilities shall be supplied, he also must have the opportunity to learn to spend money wisely for such experiment. In general, if engineers are backed up with proper facilities and properly apportioned developmental budgets, they will be only too eager to do the requisite technical study and to take advantage of appropriate educational opportunities. Without such facilities, however, the engineer cannot develop technically.

Nevertheless, it is most important that management should so organize that engineers will have more than one path to follow toward both economic and social rewards. It must be recognized that some engineers can and should make their greatest contribution in supervising other engineers and in managing certain segments of the engineering work, while other engineers can perform their greatest accomplishments by concentrating on themselves and attaining pre-eminent technical skills as specialists. Both paths to success should be clear, open, and a part of the organization plan. Some men will follow one path, some the other; some may follow both. However, only by recognizing outstanding technical individuals both socially and economically on the same level with their supervisory or managerial counterparts can young men be encouraged each to follow the path which for him is proper. This does not mean that the whole judgment should be that of the individual engineer. Management and those in supervision have a continuing responsibility for guidance in this respect. Increasingly, also, as scientific tools for the measurement of ability and interest of human beings become available, these tools should be applied in making this judgment function properly.

Recognition. Continuous recognition is as important to the engineer as to any other employee. In the case of the engineer, an important factor in demonstrating true recognition involves a continuous process of keeping him informed—informed not only on policies affecting him directly such as technical matters, or pay; but also on general department and company progress, or lack of it; on labor relations; profit position; and a host of other such matters.

PROFESSIONAL DEVELOPMENT

THE THIRD AREA of broad management responsibility in the development of the engineer comes in what is rather loosely known as his professional development. While the older technical societies are broad in scope, there is an ever-increasing number of active societies of more specialized interest. Management should have a definite and constructive program for encouraging engineers to participate in the activities of appropriate societies. Such society participation not only represents the attainment of professional and social recognition but in a very real sense broadens and deepens the technical understanding of the engineer.

The preparation of technical papers and participation in the work of technical committees are valuable mental disciplines as well as means to recognition. Nevertheless, this is an area in which good judgment is required and no company can set itself up to dictate. In the author's opinion, however, a company employing engineers should be concerned by and with the extent to which its engineers become members of and have appropriate voices in the local and national proceedings of technical societies. On the other hand, it is self-evident that some engineers must work on highly confidential projects, some classified for reasons of national security, while others are zealously guarded from becoming common knowledge of competition. Other engineers may work on equally important problems or projects which can and should be generally disclosed, thereby contributing to the over-all benefit of society without impairing national security or the competitive drive which is the mainspring of our industrial progress. Management should recognize these factors and, by assistance to the engineer in achieving professional recognition wherever possible, compensate for the occasions when unusual circumstances may prevent such recognition.

DEVELOPMENT OF LEADERSHIP IN SOCIETY

Finally, it seems evident that the management of a company employing a large number of engineers should give substantial thought to and prepare concrete plans for the economic and even the political education of engineers. Much has been said in the proceedings of the technical societies on the extent to which the engineering profession can, does, and should participate in the decisions of government. The first requisite of such participation is economic sophistication; that is, an understanding of basic economics which cannot be obtained except by substantial study of the same kind which is given to mathematics or physics. Hence, part of the program of the General Electric Company is to make available to our professional people—regardless of whether they choose the path of management or technical specialization—the opportunity for study of basic economics. This is done in a practical manner with a variety of courses. Two outstanding courses were prepared outside our company and two internally. One of these (and in many cases more than one) is given to all technical and supervisory people.

In regard to political education, we are now in an era in which the sphere of influence of central government has increased many, many fold. The basic impulses causing this increase in the main have been of an economic nature. Therefore, the understanding of simple economics is a prerequisite to political understanding. This, of course, does not mean that management has the responsibility to teach engineers to have a uniform set of party loyalties or beliefs. Rather, management should see to it that engineers as well as other educated people have not only an opportunity but the encouragement to develop themselves along the lines of understanding the economic and political atmosphere in which the corporation which employs them lives. Without this they cannot be expected to appreciate the degree and extent to which the present social trends can influence and are influencing both the contribution they can make to society and the reward which society feels is appropriate for the contribution. Such education can and often should be supplemented by the encouragement of participation in civic affairs.

SUMMARY: BUILDING BLOCKS OF MANAGEMENT POLICY

To summarize in brief, a proper plan for the development of engineers should include:

1. A plan for their selection.
2. A plan for specialized training and orientation and appropriate evaluation upon first coming to work.
3. A plan for advanced technical education appropriate to the aims and objectives of the company applicable to the first few years of employment.
4. A logical and effective plan of organization involving a minimum of supervisory layers, very few undefined responsibilities, and staffing by men with a clear understanding of their supervisory and management responsibility.
5. A continuous system of properly appraising the contributions of the individual engineer.
6. A strong interest in the engineer and a means for effectively guiding him along either the path of supervision and management or on the path of individual technical attainment.
7. The necessary and appropriate means for assisting the engineer to become more competent in either of the paths described in item 6 beyond that which can be obtained by "on the job" training.
8. A real interest in the engineer and a plan to help him with his participation in professional societies.
9. A plan to interest and stimulate the engineer not only in a field of technical or management attainment but also in the field of economic and political understanding.

These plans then, in the author's opinion, are the building blocks which management must use in discharging its responsibility for the development of engineers.

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New York–Albany Relay System

A radio-relay system to be constructed between New York, N. Y., and Albany, N. Y., will augment existing facilities between the two cities, according to an announcement by the American Telephone and Telegraph Company, and also will interconnect with the newly constructed Albany-Buffalo microwave system to provide a second radio-relay route westward from New York City.

Initially, the new system will provide three northbound and two southbound channels for television service and one in each direction for protection and maintenance.

Comparative Cost of Distribution Systems

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THE PURPOSE OF THIS ARTICLE is to compare the effect, on the cost of new overhead, open-wire distribution systems, of using either 4.16 kv or 13.2 kv as alternative primary-feeder voltages for supplying load in the same area. The range of load densities considered is 125 to 16,000 kva per square mile. This load-density range is representative, therefore, of heavy-rural to heavy-urban loads.

At a given load density, costs of distribution systems employing either 4.16-kv or 13.2-kv primary feeders are based on a system in which, for either primary-feeder voltage, similarly arranged primary-feeder circuits are extended until 3-per-cent voltage drop, or the kilovolt-ampere loading limit of the primary feeder is reached, whichever occurs first. The cost of a distribution system in which 4.16-kv primary feeders are loaded to a maximum of 2,500 kva is compared with the cost of three different distribution systems for the same load density, employing 13.2-kv primary feeders, loaded to a maximum of 2,500, 5,000, or 7,500 kva. The actual load densities considered are 125, 250, 500, 1,000, 2,000, 4,000, 8,000, and 16,000 kva per square mile.

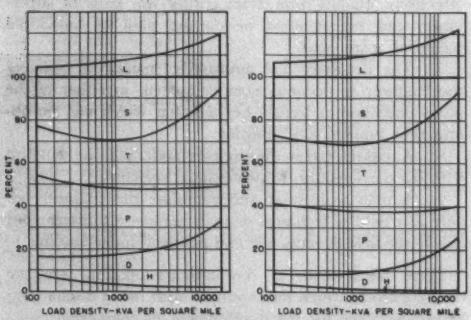

Figure 1 (left). Per cent of total distribution system cost allocated to each component, and capitalized losses. 4.16-kv primary feeder voltage. Maximum allowable primary-feeder loading of 2,500 kva. Figure 2 (right). Per cent of total distribution system cost allocated to each component, and capitalized losses. 13.2-kv primary-feeder voltage. Maximum allowable primary-feeder loading of 7,500 kva

H—Subtransmission circuits
D—Distribution substations
P—Primary-feeder circuits
T—Distribution transformers
S—Secondary circuits
L—Capitalized losses

The total distribution system cost is considered to be the sum of the costs for high-voltage subtransmission circuits, primary distribution substation, primary-feeder circuits, distribution transformers, secondaries, and capitalized system losses. The per cent of total system cost allocated to each of these components is shown in Figure 1 for a system with 4.16-kv primary feeders loaded to a maximum of 2,500 kva, and in Figure 2 the total system cost for a system with 13.2-kv primary feeders loaded to a maximum of 7,500 kva.

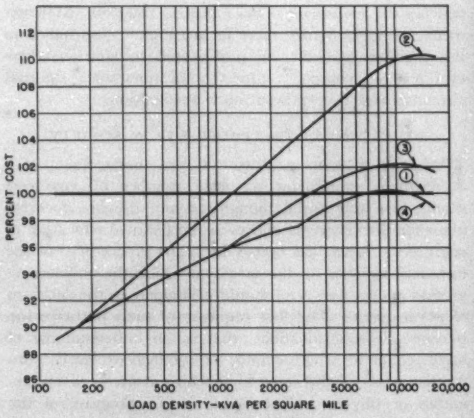

Figure 3. Comparative cost, with capitalized losses included, of alternative distribution systems employing either 4.16-kv or 13.2-kv primary-feeder voltage

(1) 4.16 kv, maximum allowable primary-feeder loading of 2,500 kva
(2) 13.2 kv, maximum allowable primary-feeder loading of 2,500 kva
(3) 13.2 kv, maximum allowable primary-feeder loading of 5,000 kva
(4) 13.2 kv, maximum allowable primary-feeder loading of 7,500 kva

In Figure 3, the comparative total costs for the four systems indicate that in light-load-density areas, where primary-feeder voltage drop is the factor that determines the allowable loading of primary feeders, 13.2 kv is economically favorable. As a primary-feeder voltage, 4.16 kv becomes more favorable economically as load density of the system increases, and as the kilovolt-ampere loading limit of the alternative 13.2-kv primary feeders of the system is reduced.

Digest of paper 53-79, "Comparative Cost of Distribution Systems With 4.16-Kv or 13.2-Kv Primary Feeders," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Not scheduled for publication in AIEE *Transactions*.

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Insulation Co-ordination

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Certain changes in United States practice are proposed, while the practices in the United States and Canada are presented for the benefit of engineers of other countries.

THE CHOICE of equipment insulation is dependent upon the magnitude of voltage permitted by the protective equipment. In 1941, by joint action of AIEE, Edison Electric Institute (EEI), and National Electrical Manufacturers Association (NEMA), a list of basic impulse insulation levels was established from which all insulation levels were to be chosen. More recently this problem has been attacked anew, and on May 29, 1950, by joint action of these same organizations, agreement was obtained upon a set of values for insulation levels of 450 to 1,050 kv, inclusive. This action recognized the excellent operating experience obtained with reduced insulation on systems with good grounding conditions and to this end introduced a new level of 825 kv, intended for 230-kv systems with exceptionally good grounding. The work of the triple-joint committee is continuing for systems of lower voltage. International standardization, through the International Electrotechnical Commission, is also in progress. Because of the differences in system voltage in different countries, as well as the variation in emphasis placed on different operating practices, international standardization presents a more difficult problem.

It is the purpose of this article to present the opinions and methods of approach of one group of individuals working on this problem in the hope that this analysis will assist in the understanding of the problem and promote the cause of national and international standardization of insulation levels. Basic impulse insulation levels above 1,050 kv are not considered here since preferred system voltages have not been designated. The authors suggest, however, that the same philosophy of protection presented here be applied in establishing the higher levels.

LIGHTNING ARRESTERS

Types. In both the United States and Canada insulation co-ordination centers largely around the characteristics of lightning arresters. There are three classes of lightning arresters for the protection of apparatus: station, line, and distribution. Station and line arresters are of the valve type, whereas distribution arresters may be of the valve or expulsion type. All lightning arresters are rated in terms of 60- or 50-cycle voltage. The voltage rating designates the maximum rms voltage of system frequency, applied across the arrester terminals, against which it can interrupt its power follow current and restore itself to an insulator once discharged by a surge. Valve arresters have a voltage rating only, because they themselves determine their follow current. Expulsion arresters have, in addition, fault current ratings since their follow current may depend not only on the arrester, but on the system characteristics as well.

Characteristics. The protective characteristics of expulsion arresters are determined by their impulse sparkover voltages. The voltage during the flow of discharge current, called discharge or residual voltage, is low and need not be considered. In the case of valve arresters, the discharge voltage is the significant protective characteristic for purposes of co-ordination. The impulse sparkover voltage of valve arresters usually is less than the discharge voltage, and in addition, its duration is so short that it becomes unimportant.

The discharge voltages of arresters are stated in terms of the crest voltage reached during the discharge of an impulse current of 10×20-microsecond wave shape. The wave shape of the corresponding discharge voltage approximates the 1.5×40-microsecond waveform in terms of which the withstand voltage of insulation is specified. For station-type arresters, the maximum discharge voltage crests at 5,000, 10,000, and 20,000 amperes are approximately 3.67, 3.95, and 4.30 times the arrester rated rms voltage. Similarly, for the line-type arresters, the discharge voltages for 5,000, 10,000, and 20,000 amperes are, respectively, 4.68, 5.18, and 5.69 times the rated voltage. In this article, co-ordination is based on the discharge characteristics of station-type arresters. Other types of arresters may be used in practice; however, the differences in performance should be recognized.

Selection of Arrester Rating. In order to determine a protected level, not only must the impulse characteristics of arresters be known, but the rating of the arrester must be selected. The proper rating depends on the maximum system voltage and the system characteristics, especially the type of system grounding.

On systems where neutrals are isolated, it is customary to use arresters whose ratings are at least as high as the maximum operating phase-to-phase system voltage. These arresters generally are called 100-per-cent arresters.

On systems whose neutrals are grounded, there exist various possibilities of arrester ratings, depending on the system characteristics and the arrester location. Systems grounded through high impedance or Petersen coils require 100-per-cent arresters. On low-impedance grounded sys-

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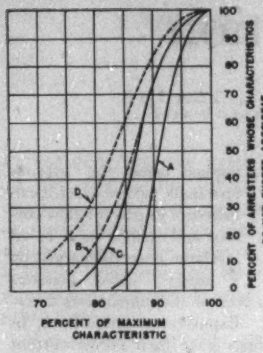


Figure 1. Probable distribution of protective characteristics of lightning arresters. These distributions are truncated, that is, limits are fixed. These curves do not apply to arresters for rotating machines. A. Station type, discharge voltage; B. Station type, impulse sparkover; C. Line type, discharge voltage; D. Line type, impulse sparkover

tems, lower arrester ratings may be satisfactory. When the maximum dynamic voltage to ground on any phase is limited to 80 per cent of the normal line-to-line voltage, a so-called 80-per-cent arrester is applicable. This is an arrester whose rating is 80 per cent, or the next higher standard rating, of the rating usually used on isolated neutral systems. If the system impedances are such that X_0/X_1 ratio is less than three and the R_0/X_1 ratio does not exceed one, then the maximum line-to-ground voltage that appears on any phase during fault conditions will not in general exceed 80 per cent. Such a system is usually referred to as being "effectively grounded." The large majority of systems in the United States operating at 115 kv or higher are effectively grounded.

Even lower rated arresters are sometimes applied. In each application the possible overvoltage must be calculated to minimize the possibility of arrester damage. Limits have not been generally agreed upon for X_0/X_1 and R_0/X_1 ratios for these lower rated applications.

The 4-wire distribution system, in which the neutral wire is carried to each transformer and grounded at least at each transformer, generally utilizes arresters 75 per cent or less, a practice developed largely from experience.

Where reduced-rating 80- or 75-per-cent arresters are applicable, the protective levels are lowered correspondingly, thereby affecting the co-ordination. In this article, applications will be referred to as 100, 80, or 75 per cent.

Station-type lightning arresters of modern construction are relied upon to a high degree in the design and operation of electric systems. They have excellent service records. When properly applied, the rate of damage to arresters is about one in 10,000. The rate of damage to station-type arresters has been decreasing considerably, not only because of improvements in their construction, but also because the major system causes of arrester damage are being eliminated. The rate of damage to line and distribution types of arresters is higher, probably because of their lower discharge capacity and possibly because the user may accept a greater risk in the application of these types. Some 20 years ago the record was not as good. The accumulation of moisture in arresters then contributed considerably to arrester damage. This is no longer a cause of concern.

PROTECTED LEVELS AND MARGINS

WITH THE ARRESTER RATING determined for any particular location, it is next necessary to set up the conditions under which the arrester will operate so that the voltage to which the equipment will be exposed can be determined. Two general types of application are recognized.

1. Substation protection.
2. Line equipment protection.

Substation Protection. Most transmission lines and substations, particularly for those above 69 kv, are protected against lightning by means of ground wires. It has been estimated, based upon records obtained by numerous investigations, that, for the discharges of arresters located in stations, only 4 per cent exceed 5,000 amperes crest and only 1 per cent exceeds 10,000 amperes crest. The probability of occurrence of these discharges for each arrester is one every 14 years for 5,000 amperes and one every 58 years for 10,000 amperes. A reasonable compromise for a single value of current to use in co-ordinating applications for different systems thus would appear to be a 5,000-ampere 10×20-microsecond wave. Analytical considerations indicate that the discharge currents increase with system voltage. Similarly, the discharge currents for wood-pole lines are, in general, higher than those on steel-tower lines.

A margin must be assumed above the discharge voltage corresponding to 5,000 amperes to cover the many intangible factors involved in this problem. For this purpose, an allowance of 15 per cent of the arrester discharge voltage plus a constant of 30 kv will be taken. The constant of 30 kv is intended to cover the voltage drop in the arrester downlead and in the arrester ground. This will be assumed to be independent of the system voltage. The 15-per-cent margin is based upon an estimate of the most severe conditions to be encountered. A strong element of judgment, based upon operating experience to date, is involved in this assumption. Many of the factors entering into the margin are of a probability nature and difficult of determination. It is improbable that all of the most severe conditions will occur simultaneously; they should not be pyramided one upon the other. As will be seen subsequently, the assumption of the 5,000-ampere 10×20-microsecond discharge current through the arrester plus the margin just enumerated results in a protected level that conforms closely to the basic impulse insulation levels which, in practice, have exhibited excellent performance.

To the extent outlined in the two steps just mentioned. the assumptions made for the lightning arrester discharge current and the assumptions for the margins are interrelated. If more stringent discharge conditions be specified for the lightning arresters, then still to demonstrate the same acceptable co-ordination, it would be necessary to use a smaller margin between the lightning arrester discharge voltage and the basic impulse insulation levels.

It is appreciated that the foregoing approach simplifies the problem enormously. An accurate analysis attempting to take all the factors into proper accord would be extremely complicated, if not impossible. This is not to say

that the various factors entering into the problem should not be studied individually.

Some of the factors entering into the foregoing assumptions are

1. *Wave shape of discharge current.* The wave shape of the arrester discharge current affects the crest amplitude and the wave shape of the discharge voltage. A rate of rise of 5,000 amperes per microsecond with a crest current of 5,000 amperes has been suggested by some as a more suitable discharge current upon which to base co-ordination. This would be a departure from a practice on which all our experience rests. There is no published evidence that a discharge current of this character has been obtained through an arrester in the field that has been connected to a transmission system supplied with a ground or shield wire. Such a wave is difficult of attainment in the laboratory. The authors do not favor this suggestion. Since so many factors are involved, it appears unwise to put too much emphasis on the 5,000-ampere-per-microsecond rate of rise which evidence from the field indicates does not occur frequently in shielded systems.

2. *Shielding.* It has been assumed that both the substation and the transmission line are protected by a ground wire. The absence of station and line shielding will increase the probability of high currents in the arresters. This is particularly true for the shielding over the station and the first few spans of line.

3. *Separation between the arrester and protected equipment.* It is desirable that the arrester be located as close as possible to vital equipment. In some cases, more than one arrester is required to assure protection of the substation. Such factors as the magnitude and the rate of rise of the incoming voltage waves, the length of the downleads to the transformer and to the arrester, the separation between the protected equipment and the downlead, the presence of additional outgoing lines, and the length of stub end busses; all affect the magnitude and wave shape of the voltage at the protected equipment.

4. *Insulation characteristic.* The major insulation of transformers is such that for chopped waves the withstand voltage is about 15 per cent greater than for the full-wave value. This turnup of the insulation value for short times can be regarded as a favorable tolerance, but must be considered simultaneously with the wave shapes obtained when separation factors are analyzed.

5. *Probability of lightning arrester manufacture.* In view of the probable distribution of discharge voltages shown in Figure 1, it has been proposed that co-ordination be based not on the maximum to be expected, but a lower arrester voltage. With this the authors do not agree, but believe that discharge voltages below the maximum should be regarded as an additional favorable tolerance included with the other factors entering into the margins. A similar objection applies to taking advantage of a possible lower arrester voltage characteristic arising from the fact that a large number of elements are used in series.

6. *Probability of manufacture of the protected equipment.* Although the insulation of the protected equipment is rated on a minimum basis, in the variabilities of manufacture and in the necessities of design, certain margins are involved. These margins exist with even more reason than the arrester margins, as the arrester probability can be controlled by test in the course of manufacture. There is no way of determining the actual insulation breakdown strength of solid insulation without destruction. The authors are not proposing that this region be encroached upon, but merely state that this region does exist and should be recognized.

From the foregoing it is quite evident that for usual applications it is quite impractical to approach the problem other than through an assumption such as indicated, namely, adopt a reasonable discharge current through the lightning arrester and a margin above the discharge voltage resulting with this current through the arrester.

Having decided to base the protected level on the

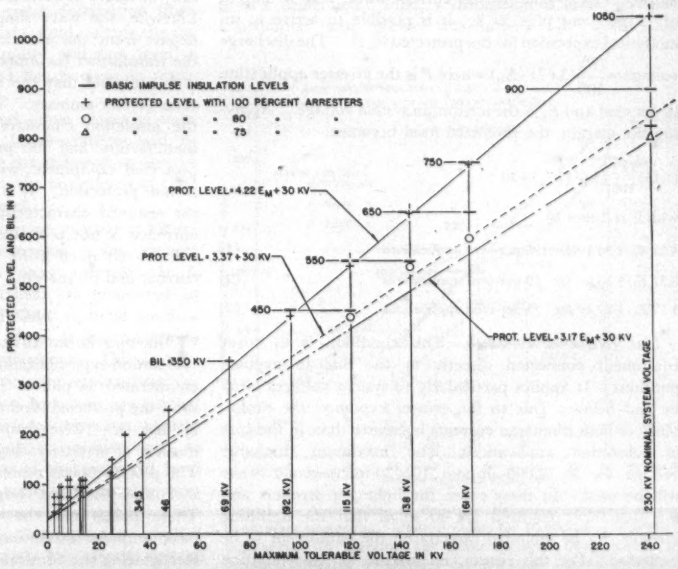
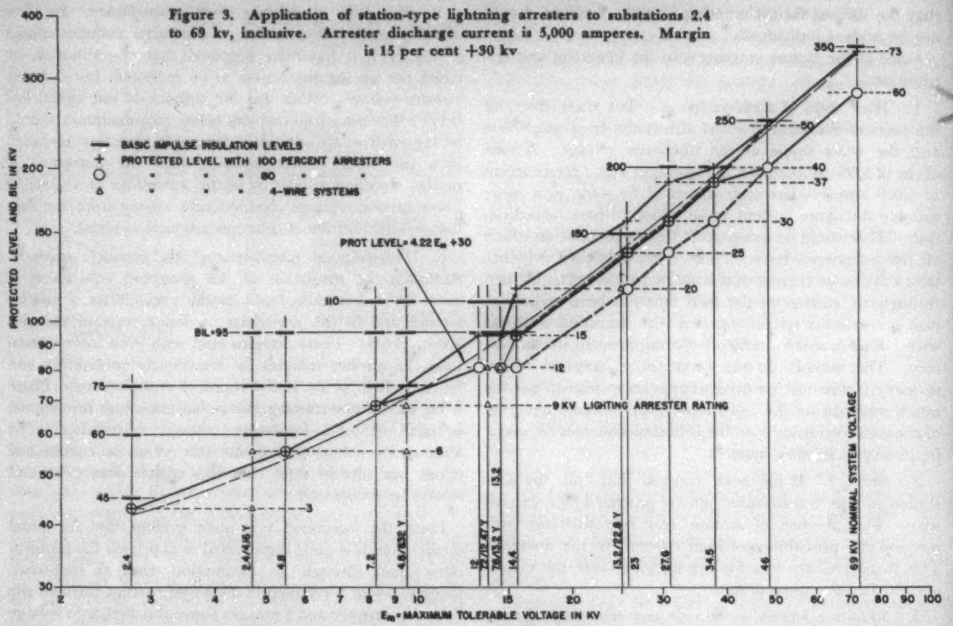


Figure 2. Application of station-type lightning arresters to substations 115 to 230 kv, inclusive. Arrester discharge current is 5,000 amperes, 10×20 wave. Margin is 15 per cent +30 kv

Figure 3. Application of station-type lightning arresters to substations 2.4 to 69 kv, inclusive. Arrester discharge current is 5,000 amperes. Margin is 15 per cent +30 kv



voltage of a station arrester when discharging a 5,000-ampere 10×20-microsecond current wave, with a margin of 15 per cent plus 30 kv, it is possible to arrive at an analytical expression for the protected level. The discharge voltage $= \frac{(P)}{100}(3.67)(E_m)$ where P is the arrester application in per cent and E_m is the maximum system voltage. Applying the margin, the protected level becomes:

$$(1.15)\frac{(P)}{100}(3.67)(E_m)+30$$

which reduces to

$4.22\,E_m+30$ kv for 100-per-cent applications (1)

$3.37\,E_m+30$ kv for 80-per-cent applications (2)

$3.17\,E_m+30$ kv for 75-per-cent applications (3)

Line Equipment Protection. This condition is to cover equipment connected directly to the line in exposed positions. It applies particularly to system voltages of 69 kv and below. Due to the greater exposure, the probability of high discharge currents is greater than in the case of substation applications. The maximum discharge voltage for a 20,000-ampere 10×20-microsecond wave will be used. In these cases, the lightning arresters and the clearances required are so small that the lightning arrester can be mounted directly on the equipment to be protected. For this reason, no margin for co-ordination purposes is necessary. This is not to say that many of the factors enumerated in the foregoing will not be present. The magnitude of the current discharged by the arrester may be larger or smaller than the assumed 20,000 amperes. Likewise, the wave shape of the discharge current may depart from the assumed 10×20-microsecond wave. If the transformer is connected to a system which is shielded, it is probable that the discharge current will be smaller than 20,000 amperes. The same probabilities relating to the insulation characteristic, the probability of arrester manufacture and the probability of manufacture of the protected equipment, will apply to this case as for substation protection. It is assumed that the departure from the assumed characteristics is such that simultaneous occurrence is not probable and that satisfactory protection will be obtained with the assumed arrester discharge current and no margin.

PROTECTED LEVELS

THE PROTECTED LEVEL OF substation equipment using station-type lightning arresters for the conditions just enumerated is plotted in Figure 2. The straight lines show the protected level obtained according to equations 1, 2, and 3. These formulas assume an infinitely large number of arrester ratings from which to choose arresters. The plotted points represent the protected levels obtained by using the next larger standard lightning arrester. These points may be compared to the corresponding basic impulse insulation levels that are now standard. Recognizing the admirable performance obtained with this type of arrester with the standard basic impulse insulation levels, the assumptions for arrester discharge current and

margins are fully justified. The abscissa for this figure is plotted against the maximum tolerable voltage which, for all system voltages in excess of 34.5 kv, is 5 per cent greater than the nominal system voltage.

Due to the difficulty in discerning the points in the lower range of voltages in Figure 2, Figure 3 has been prepared for this range. The analytical expression for 100-per-cent applications has been drawn for orientation. In the United States, in this range of system voltages, no attempt is made to economize on insulation because of grounding the system. This results because the disadvantages of a greater number of levels absorb such advantages that might result from introducing less material in the equipment. The crosses indicate the protected levels that can be attained with arresters. Between systems of 14.4 kv and 34.5 kv, two alternate arresters are used. In this range, with the higher rated arresters, the protected level of two systems lies above the corresponding basic impulse insulation levels. This is particularly pronounced for the lower level basic impulse insulation level in the 14.4-kv system. The protected level provided by the lower rated arresters in this range is well co-ordinated with the corresponding basic impulse insulation levels. However, these lower rated arresters in all cases have a rating just slightly below the maximum tolerable system voltages, and should not be applied unless it is known that the system voltage at the particular point of application is lower.

The advantage of the grounded neutral system is quite evident. It permits the use of a sufficiently low rated arrester so that protection is positive and at the same time the arrester is not endangered.

Of recent years the 13.2/22.8 Y system has come into considerable favor for pole-type rural distribution lines. While not widely recognized as a standard voltage, its use is growing rapidly. A basic impulse insulation level of 125 kv is regularly being supplied for distribution transformers.

The existence of the double and triple values of basic impulse insulation levels in the lower voltages will be discussed later. Let it suffice for the moment to observe that, except for the 14.4-kv system, the arresters as applied supply protection for the lowest level.

Similar data for line-type arresters are plotted in Figure 4. The same assumptions as to arrester rating, arrester discharge current, and margin were assumed. It is evident that the protection obtained, as compared to station-type arresters, is less. In many of these applications, to demonstrate protection at all, it is necessary to decrease the severity of the assumptions. This is particularly true of the 100-per-cent arrester applications.

Similar data for line equipment protection are plotted in Figure 5, using the assumptions for this case, namely a 20,000-ampere discharge through the arrester and no margin. Here also a comparison of the protected level with the insulation level would indicate incomplete protection where 100-per-cent arresters are applied. For systems of this type, the lower rated arresters are applied somewhat above their rating unless the system voltage is lower than the standard maximum tolerable value. The advantage of grounding, in permitting the use of lower

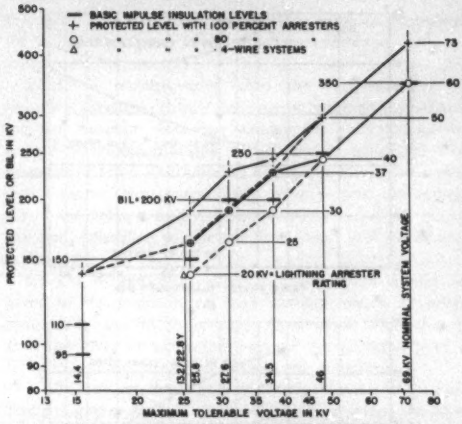


Figure 4. Application of line-type lightning arresters to substations 14.4 to 69 kv, inclusive. Arrester discharge current is 5,000 amperes. Margin is 15 per cent +30 kv

rated arresters, is well illustrated. To form an idea of the improvement in protected level for discharge currents below 20,000 amperes, the current scale has been added. By merely dropping any point by the distance shown on the arrester current scale, the protected level for a current other than 20,000 amperes can be obtained.

For system voltages of 14.4 kv and below, several important factors enter to complicate the problem of transformer protection. First, a distinction is made between distribution and power transformers. In distribution

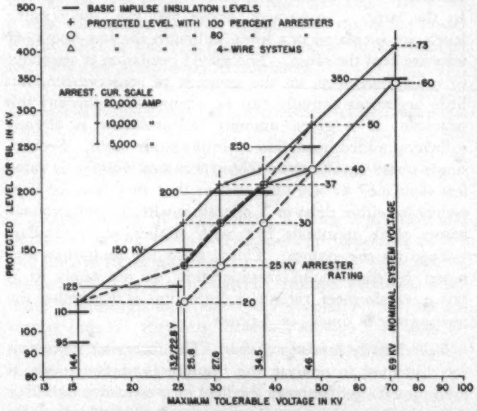


Figure 5. Application of line-type lightning arresters to line equipment protection. Plotted points for 20,000-ampere arrester discharge. No margin. For other currents drop points by distance indicated by arrester current scale. Dotted portion of curves are borderline applications and should not be used unless system voltage is lower than standard maximum tolerable

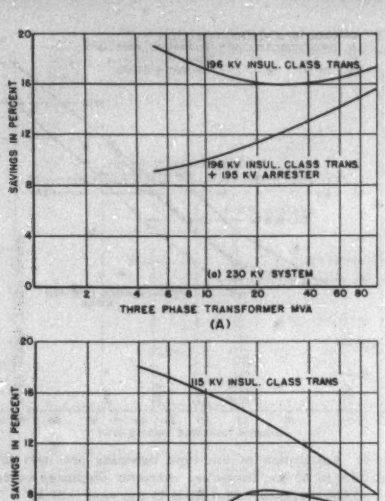

SAVINGS IN PERCENT
196 KV INSUL. CLASS TRANS.
196 KV INSUL. CLASS TRANS. + 195 KV ARRESTER
(a) 230 KV SYSTEM
THREE PHASE TRANSFORMER MVA
(A)
SAVINGS IN PERCENT
115 KV INSUL. CLASS TRANS.
115 KV INSUL. CLASS TRANS. + 121 KV ARRESTER
(b) 138 KV SYSTEM
THREE PHASE TRANSFORMER MVA
(B)

Figure 6. Typical savings in equipment cost resulting from the use of reduced transformer insulation. Savings are expressed in per cent of fully insulated transformer cost

transformers, 500 kva and below, the number of transformers being so large every effort is made to keep the insulation level as low as consistent with good protection. In the larger transformers, above 500 kva, the impulse levels are increased one level, although the low-frequency tests are kept the same. The added insulation is attractive to utility engineers on the grounds of conservatism, but little argument actually can be advanced to support this practice. If a given amount of insulation is already sufficient, added insulation is simply superfluous. Second, single-phase transformers whose terminal voltage is rated less than 8.67 kv are insulated so that they may be connected for either delta or Y operation with the same voltage across their terminals but with higher phase-to-phase voltage on the system. Third, since the limitations imposed by the second consideration do not apply to 3-phase transformers, there is a distinction as to whether the transformer is single- or 3-phase.

Basic Impulse Insulation Levels. The foregoing discussion was intended to analyze the impulse insulation levels in use in the United States in the light of present-day lightning arrester characteristics. It presents the justification for the United States values listed in Table I. In addition to those listed, a half-level of 825 kv has been approved by a joint committee of AIEE, EEI, and NEMA. An additional value of 125 kv has also found favor with some utilities for rural 4-wire systems, and while adequate protection can

Table I. Proposed International Electrotechnical Commission Standard Impulse Insulation Levels in Kv

Series I	Series II, Standard in Use in the United States* and Canada
45	45
60	60
80	75
100	95
125	110
170	150
240	200
325	250
380	350
450†	
550	
650	
750	
900	
1,050	

* In addition, the United States' Standards also include a 30-kv value and a tentatively approved value of 825 kv.

† The figures in this column are common to both Series I and Series II.

be provided for this type of equipment, it has not received approval as a standard level.

REDUCED INSULATION IN POWER TRANSFORMERS AND CIRCUIT BREAKERS

THE APPLICATION OF reduced transformer insulation, as practiced in most locations in the United States, is predicated on the basis of having the best available protection against lightning surges, which implies, in addition to adequate shielding, the installation of 80-per-cent, or lower, station-type lightning arresters on or close to the transformer. Typical savings in equipment cost that can be realized by using reduced insulation are shown in Figure 6*A* as a function of transformer rating. This figure is based on the use of oil-insulated self-cooled 3-phase transformers on a 230-kv solidly grounded 60-cycle system. Reducing the transformer insulation one class, from 230 to 196 kv, results in savings of 9 to 15 per cent, including the cost of station-type arresters. The savings in transformer cost alone exceed 16 per cent. The cost of a full-insulation class transformer without lightning arrester is taken as 100 per cent. Approximately the same savings can be realized for forced-oil water-cooled transformers as for self-cooled transformers.

At the lower transmission voltages the savings, although still significant, are not as large as at the higher voltages because insulation represents a smaller part of the total transformer cost. As shown in Figure 6*B*, the savings range between 2 and 8 per cent for the case of 115-kv insulation-class transformers and 121-kv station-type arresters applied to a 138-kv system.

It should be noted that the lower curves in Figure 6*A* and *B* assume that arresters are used with the reduced-insulation transformers, but not with the transformers employing full insulation. This rather unfavorable comparison shows that important savings can be realized by using lightning arresters and reduced insulation. The use of reduced transformer insulation without lightning arresters is not considered good engineering practice in most locations.

In the United States, the use of reduced insulation in

transformers is predicated on using 80- or 75-per-cent station-type lightning arresters. To the best knowledge of the authors, rod gaps are not used as the primary protection of transformers employing reduced insulation. The definite trend toward reduced insulation at the higher voltages will decrease the use of rod gaps for the primary protection of transformers. As shown in Figure 6*A* and *B*, lower equipment costs result with reduced insulation transformers and lightning arresters as compared to full insulation and no arresters. This is fortunate because better protection is provided and fewer outages result even with lower equipment costs.

The economies that can be realized by reducing the insulation in high-voltage circuit breakers are less than in the case of power transformers. An estimate of the savings that might be made by reducing the insulation class of circuit breakers one class indicated possible savings on the order of 12 per cent at 230 kv. The cost of lightning arresters will exceed the savings that could be realized by reducing the circuit breaker insulation for all voltages below 230 kv, which means that reduced insulation cannot be justified simply by the application of separate arresters for circuit breaker protection.

Circuit breakers, in many cases, are installed at locations subjected to the more severe surges arriving in a station. It should be noted, too, that the more common practice in the United States is to locate lightning arresters close to power transformers, which introduces considerable separation distance between the arresters and the line circuit breakers. The installation of separate arresters for the protection of circuit breakers is a practice that is not followed in the United States, excepting at the lower system voltages and in special cases at the higher voltages.

The foregoing factors limit the application of reduced-insulation circuit breakers to systems operating at voltages of 230 kv, and above, where the economies are appreciable and the separation distances, between arresters and the protected equipment, are of less importance. Many 196-kv class circuit breakers are in service on 230-kv systems.

CONCLUSIONS AND RECOMMENDATIONS

1. In the protection of substations, particular attention should be given to the shielding of the conductors against direct strokes of lightning. This may be accomplished by the erection of poles, where adjacent structures do not provide shielding, or by extending the ground wires from the transmission line over the substation.

2. Special attention should be given to the reduction of the tower footing resistances of the towers adjacent to a substation.

3. For substation application, the use of a margin of at least 15 per cent plus 30 kv between the maximum lightning arrester characteristic, for a 5,000-ampere 10×20-microsecond wave, and the basic impulse insulation level of the protected equipment is recommended. This recommendation is based upon surge protection considerations. In some cases other factors may dictate the minimum insulation requirements.

4. Where equipment is located out along the line and is protected by an arrester mounted on the equipment, the use of the maximum lightning arrester characteristic for a 20,000-ampere 10×20-microsecond wave, with no margin, is recommended.

5. It is recommended that the characteristics of lightning arresters of the valve type be specified by indicating the *maximum* discharge voltage for a 10×20-microsecond wave and that the probability of manufacture of arresters of lower characteristics be given in the form of a curve, rather than by specifying, as at present, the *average* discharge voltage and a positive tolerance of 10 or 15 per cent, according to whether the arrester is of the station or line type.

6. On hydroelectric systems, consideration should be given to the possibility of high voltage caused by overspeed following load rejection. In general, it is believed that this may be neglected because the probability of a lightning stroke during the overspeed is remote.

7. It has been demonstrated by experience and analysis that rod-gap protection is definitely inferior to that provided by lightning arresters. In some applications the use of arresters may result in a lower total investment in station equipment by permitting the use of lower insulation levels.

8. Full insulation is indicated for circuit breakers of all voltage classes below 230 kv since separation distances between breakers and lightning arresters are normally greater than in the case of transformers. Further, the savings realized by reduced insulation are not as large in the case of circuit breakers as in the case of transformers.

9. Recognizing the practical difficulties of the following suggestion, still it is recommended that some consideration be given to the reduction in the number of recognized system voltages in the range of 12.0 kv to 14.4 kv, inclusive.

10. It is recommended that the impulse test values for transformers above 500 kva, intended for systems having voltages 15 kv and below, be made equal to the impulse test values for transformers below 500 kva. In other words, this means that the impulse test values for power transformers in this range be made equal to the impulse test values for distribution transformers.

Isotopes in Power Plants

Atomic energy, in isotope form, is doing a practical and important job for the power industry in inspecting boilers and lines in steam plants and in radiographic inspection of welded seams in steam boilers. Isotope Products, Ltd., using Iridium 192, have taken radiographic pictures on operating boilers. Recently, Isotope Products have been inspecting cast sections of a turbine speed ring for a hydroelectric generating section.

Other applications of isotopes' penetrating photographic properties include examination of power transmission units such as insulators, cable joints, and pothead castings.

Thus, both in the steam generating units and in the transmission equipment which carries off the electric energy, isotope gamma-ray radiography is doing an important inspection job.

Hydraulic Servos With Hydraulic-Amplifier Value

R. L. SCRAFFORD
ASSOCIATE MEMBER AIEE

ELECTROHYDRAULIC SYSTEMS HAVE certain advantages over pure electromechanical systems which make them particularly suitable as an adjunct to electronic control for high-power-level actuation. Performance of a typical hydraulic servomechanism utilizing the Cornell Aeronautical Laboratories (CAL) transfer valve is illustrated in Figure 1.

All servomechanisms may be divided into two parts: (*a*) intelligence section which includes voltage-amplifying and phase-compensating functions, and (*b*) power output and driver stages. Section *a* contains devices which perform the various signaling and computing functions. They provide no power to the load and may accomplish intelligence transmission by means of any of the systems used by communications and telemetering engineers. Section *b* contains the power-converting devices, in which power from some energy source is transferred to the load in response to a signal from the intelligence portion of the loop.

All mechanical servomechanisms are required to accomplish some motion at the output in response to a variable at the input. This motion will be opposed, as are all mechanical movements, by the three roots of force, namely, the act of doing work, acceleration of the structure, and mechanical friction. The frequency response of the servomechanism is determined mainly by the second of these which is brought about by the mass of the structure. This mass is dictated by factors of allowable deflection for a given load, and safety factor.

Often, in electric positioning servomechanisms, the designer will find that the inertia of the load is a small fraction of the total inertia which includes that of the actuator. This is aggravated by the fact that electric motors are essentially high-speed devices usually geared down to the load. At the motor end of this gear train, then, there is the large inertia which must accelerate very rapidly.

In the low-inertia hydraulic servomechanisms, the picture is entirely different. The actuator may be conveniently designed for a wide range of speeds or for linear or rotational motion.

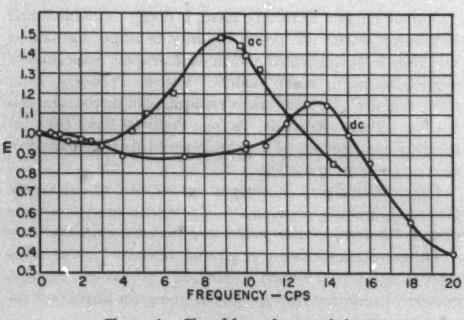


Figure 1. Closed loop characteristics

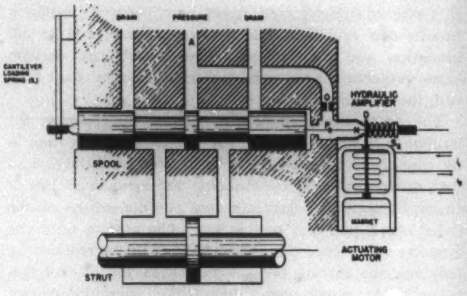


Figure 2. Valve schematic

The CAL d-c transfer valve, which falls in the category of a linear power amplifier, can be driven to full output flow rate of 30 cubic inches per second at pressures of 1,500 to 2,000 pounds per square inch with an electric signal on the order of 20 milliwatts into one side of its center-tapped input impedance of 6,000 ohms. The time constant of the valve is on the order of 3 milliseconds. The a-c model requires greater driving power.

The CAL transfer valve is shown schematically in Figure 2. Hydraulic pressure is applied at A. There is a very small amount of hydraulic flow past the orifice O, into the chamber P_c, and out the nozzle N. Control of oil flow through the nozzle is by the flapper D, actuated by an electric device. Pressure drop along this path is shared between the orifice and the nozzle. Chamber pressure is then 750 pounds per square inch and the centering spring may be adjusted to give zero flow.

Now, if a signal is applied to the coils of the electric actuator, the flapper will move in or out, either increasing or decreasing the nozzle pressure drop and, hence, the chamber pressure. An increase in chamber pressure results in the valve spool being moved to the left against the spring until a new force balance is obtained. A decrease in chamber has the opposite effect. The result is linear control of the flow of oil. Nozzle flow is small and kept inside the unit.

Although the advantages of hydraulic control have been recognized and applied in the aircraft industry, there have been few applications in the field of industrial control. It is the belief of the author that hydraulic systems incorporating this valve would result in superior solutions to problems in many instances.

Digest of paper 53-103, "Hydraulic Servos Incorporating a High-Speed Hydraulic-Amplifier-Actuated Valve," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Nuclear Power Plant Control Considerations

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The general considerations affecting nuclear power plant control-system design are reviewed. Special emphasis is placed on the features of reactor control.

THE DEVELOPMENT procedure for designing the control system for a nuclear power plant is basically the same procedure as for any other type of power plant. However, the presence of a nuclear reactor as a component in the system imposes many unusual design problems. The basic method of approach to control-system design consists first of studying the plant operational and control requirements. Following this review a preliminary block diagram of a control system to fulfill these requirements may be attempted. However, after a study of this diagram, it often becomes apparent that the inherent dynamics of the plant and the characteristics and limitations of some of its components are of utmost importance. Modifications are then made to the proposed block diagram. Once the desired operation of the control system is fully understood, the problem of synthesizing the control system can begin.

At the present state of the art, the problems introduced by the reactor necessitate more study than do the conventional ones. Considerable literature has been written about reactor control,[1–4] but very little is available on the control of power plants employing a reactor.

PLANT OPERATIONAL REQUIREMENTS

CERTAIN INFORMATION must be known concerning the operation and output of the plant. These operational requirements are usually given in the basic plant specification.

For the sake of illustration an elementary block diagram of a possible nuclear power plant is shown in Figure 1. Here the reactor is considered merely as a source of heat energy. When this heat is extracted by passing a coolant through the reactor, the heat energy is then transferred via a heat exchanger to a turbine system, and the output shaft of the turbine can be made to drive many types of working apparatus. The primary coolant considerations are basic for control design, and it may be mentioned in passing that gas, water, and liquid metals have been proposed as reactor coolants.

The ultimate usage of the system of course determines the specified-output requirements. A useful principle of control design is to attempt to place the primary operating controller near the output of the system. Consequently, the characteristics of the output loading as a function of turbine horsepower output is of first interest. In the case of an aircraft power plant this information might be specified in terms of aircraft speed as a function of turbine output. For a shipboard plant the information might be supplied in the form of propeller revolutions per minute versus turbine output. In any case an understanding of the relationship between the turbine and the load output is necessary to plant control.

Another factor affecting the type of control system is the operational transitions required. These transitions determine the range of control and the output-level variations required. Minor consideration is given to whether the final output is to be continuously variable, variable in steps, or some combination of the two.

Startup and shutdown requirements affect the control system. Here the nuclear reactor plays a prominent part in determining plant performance, for nuclear reactors cannot be started up too fast and never can be really shut down. In considering the output of the nuclear reactor, there is no such thing as "zero power" involved. Even in a new cold clean reactor which has been shut down as much as possible, an inherent source of neutrons exists which causes a certain amount of nuclear fission to occur. This fission produces minute amounts of power and in the process more neutrons are released. This effect requires

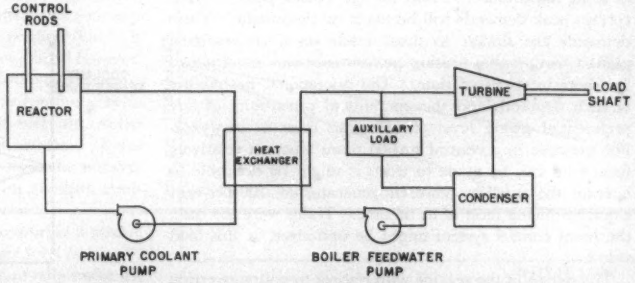

Figure 1. Elementary block diagram of possible nuclear power plant

Essentially full text of paper 53-51, "Nuclear Power Plant Control Considerations," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Acknowledgment is made of the assistance rendered by J. C. Simons, J. N. Grace, and G. H. Conley of the Atomic Power Division, Westinghouse Electric Corporation.

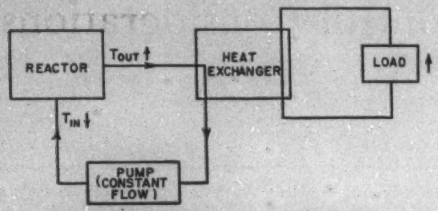

Figure 2. Simplified power-plant block diagram with reactor having a negative temperature coefficient

that the reactor neutron output be monitored continually to see that the neutron level is kept under control. In practical cases this monitoring means that instrumentation for measuring neutrons must be capable of operating over ranges as wide as 6 to 10 decades and control provisions must be provided over a similar range. Starting up a reactor from a cold condition means that the reactor can operate over a neutron range of many decades before any appreciable useful power begins to occur at the output. Some arbitrary number of neutron fissions has to be taken as zero power. For example, 1 per cent of full-load output might be considered to be the equivalent of zero power. Transitions between 1 per cent and 100 per cent full power can be made relatively rapidly, but because of the safety aspects involved, transitions from a cold startup must be made quite slowly.

A reactor which has been operating at a high power level is turned off neutronwise by manipulating the reactor control rods to reduce the reactivity of the reactor. However, many secondary radiations, particularly gamma rays, exist from the formed fission products. The amount of power from these secondary radiations is in some instances very substantial. Consequently, although the reactor has been turned off to the best of the ability of the operator, serious amounts of power still may be given off for a considerable length of time. Controlwise, this condition means auxiliary devices may be necessary to dump this spare power into a useless load. It can be seen therefore that the startup and shutdown of a nuclear power plant is dependent upon the reactor characteristics and differs from conventional plant techniques.

The transient output requirements of the plant are also of some importance. From an operational point of view certain peak demands will be made on the system. These demands are similar to those made on a conventional plant whereby above-rating performance can be obtained for short intervals of time. The operational probability of such demands and the operational probability of any preferential power level of operation must be analyzed. For example in a central station plant where a relatively fixed load can be made to exist, it might be desirable to operate the nuclear powered generator at 100-per-cent capacity during most of its lifetime. If this were the case, the plant control system might be optimized at this load value.

The design of the reactor with respect to poison override is another important operational-control consideration. When some types of reactors are shut down, nuclear poisons are known to build up and reduce the over-all reactivity of the reactor. In time these poisons ultimately die away. A certain amount of additional reactivity can be designed into a reactor to override this poisoning effect. The amount of the poisoning override which is built into the reactor becomes an operational factor because, with only a small amount of override reactivity in the system, the poisons can build up in a given amount of time to an amount capable of making the reactor inoperative. Before this time is reached the reactor might be turned back on and the poisons effectively burned out. If, however, the reactor poisons have built up to such a level that the plant cannot be turned on, it then becomes necessary to wait until the poisons die down to where the reactor again can be made critical. To build enough reactivity into a reactor always to override the poisons may require a large amount of fissionable material. If the service to which the power plant is put is such that the plant must be shut down frequently for critical periods then some other means must be found for supplying auxiliary power during the dead-off time of the reactor.

Another of the factors which is involved in the design of control components is the reactor and plant lifetime. Contrary to popular opinion, reactors do not have an indefinite life. The uranium atoms which are involved in the fission process become used up and although a tremendous amount of energy is available each time a uranium atom is fissioned, ultimately enough fissions occur so that the reactor becomes depleted in uranium and no longer will maintain a chain reaction. Other factors, such as radiation damage to the structural material of the reactor or the corrosion of any portion of the mechanisms, may cause the end of life of the reactor. If the design of the plant can be made such that all components have an effective indefinite lifetime compared with the lifetime of the reactor, it then may be feasible to employ some means of changing the fuel or of possibly even changing reactors.

PLANT CONTROL REQUIREMENTS

Once the over-all characteristics required of the plant have been specified, certain of the details of these characteristics pertaining directly to the control system can be examined. Detailed control information is needed about the steady-state output error that can be tolerated. That is, how important is it that the plant give

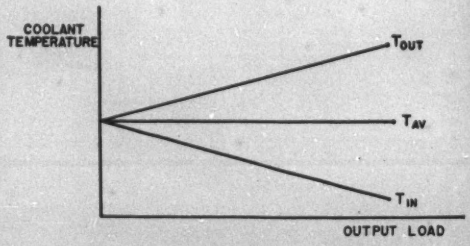

Figure 3. Steady-state temperature pattern

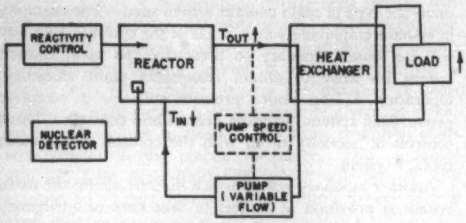

Figure 4. Block diagram of system maintaining primary coolant outlet temperature constant

out a fixed number of kilowatts or given propeller revolutions per minute and hold this output regardless of operational transients. The steady-state output error directly specifies the tolerable steady-state plant-instrument errors. Frequently, control systems are devised whereby the errors of many instruments in many loops add up to produce a higher probable error than the over-all specifications permit. On the other hand it is possible in the design of certain loops to integrate out instrument errors in such a manner that they do not show up in the final output. From the over-all error permitted, the designer can work backwards through each loop figuring the steady-state error that conventional control components will impose upon the system.

Similarly, certain plant and reactor transient errors may be permitted for some of the instruments. For example, if two thermometers are used in the system and one thermometer has a much larger time constant than the other, it is obvious that in a transient change both of these thermometers will not read identically. If these instruments are used in control loops, the output of a particular loop may temporarily permit an error to exist in the plant output.

One control requirement which is peculiar to the nuclear power plant is the instrumentation setup for alarm, cutback, and "scramming" circuits. Alarm circuits are common in the power industry, but the peculiar notion of "scram" is one limited to the reactor field. A scram in reactor parlance consists of an attempt to insert as much negative reactivity as possible into the reactor in as short a time as possible. Practically, a scram usually means injecting safety rods into the reactor with some violence. The safety requirements of the reactor are such that it is usually necessary to employ scramming devices. However, from a practical power point of view, it is obvious that the plant must be kept in an operable state as continuously as possible. The plant must not be shut off every time some minor control in a secondary loop malfunctions. Therefore the control designer's problem is to limit the number of controls which can cause a scram to an absolute minimum.

For all accidents other than the type requiring a scram, it is possible to cut back the reactor power level or merely to ring an alarm and have an operator manually make the necessary adjustment or shutdown.

PLANT DYNAMICS

THE HEART OF the control-system problem is the primary coolant-system operating cycle. There are many patterns into which the temperature and the flow of the coolant coming in and out of the reactor may be manipulated to produce the desired output power. The system operating cycle may be determined by many items such as auxiliary requirements, corrosion, or peak temperatures permitted. However, in a control system designed about a reactor one should attempt to follow this basic premise. *If the reactor has a negative temperature coefficient, the reactor system preferably should have the average coolant temperature constant.* A word of definition is necessary concerning the reactor temperature coefficient. To say that a reactor possesses a negative temperature coefficient means that as the reactor average temperature increases its over-all reactivity decreases. That is, the chain reaction will slow down with increasing temperature. This condition is obviously desirable.

Examine the simple plant shown in Figure 2 in the light of this premise. This illustration shows a primary coolant being circulated at constant flow through a reactor having a negative temperature coefficient. A steady output is being produced, and now suppose that more output is required by the load. This greater loading causes more heat to be extracted from the heat exchanger and for a short period of time the heat capacity of the heat exchanger can usually supply this load. However, the additional energy extracted from the system requires that the temperature of the coolant into the reactor must drop. If the reactor has a negative temperature coefficient as defined in the foregoing, the dropping of the coolant temperature inserts more reactivity into the reactor. If the reactor was initially in a critical state it now temporarily becomes supercritical. More energy is then available from the reactor, and consequently the output temperature of the coolant rises, and in the steady state the reactor returns to its critical condition with the average coolant temperature the same as it was initially. These steady-state temperature conditions are shown in Figure 3. It will be noted that without any control mechanism whatever the reactor system has stabilized itself about a given average temperature and automatically supplied any reasonable demand put upon it. This is the case only where the program of

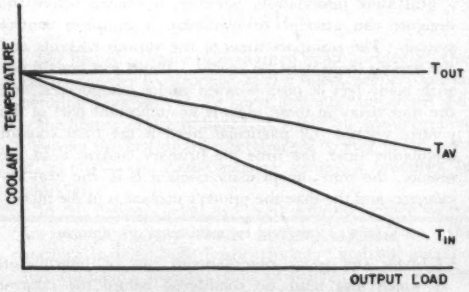

Figure 5. Steady-state temperature pattern

primary coolant operation is such that the average coolant temperature remains constant.

Let us assume now for some reason other than the reactor control system it is desirable to establish a different pattern of coolant temperatures. A reasonable pattern might be that shown in Figure 4. This illustration shows a simple system which might be called for by some structural condition desiring to keep the outlet temperature fixed at a given maximum level. Figure 5 shows a block diagram of how this condition might be achieved. Again if more load were required the inlet temperature to the reactor would drop. More reactivity would be inserted in the reactor because of the negative temperature coefficient. The outlet coolant temperature would tend to rise, but now a control has been inserted on the outlet temperature which measures the temperature and then varies the coolant pump speed in such a manner so as to reduce this outlet temperature. In this manner it is very feasible to hold the outlet temperature constant as a function of load as seen in Figure 4. However, it will be noted that the average coolant temperature drops with load meaning that the reactor, because of its negative temperature coefficient, would tend to operate in a supercritical condition. Consequently another control loop, usually rod control, must be added to the system to extract the reactivity put in by the change in coolant temperature.

The system of Figure 5, from a control point of view, compares unfavorably with the previous system. Here the external control systems which have been added cause the reactor system to operate in a manner contrary to its own inherent stability. Consequently, the system is not quite as safe and requires considerably more control equipment. Neither of the simple systems described is completely practical for an actual plant, but many derivatives and variations can be derived which will fulfill the required specifications in a compromise manner.

Once the primary system operating program has been determined, it would be very desirable to have the transfer functions of all of the major system components available. Unfortunately, in the present state of the art the control designer must be satisfied with far less. Usually a simplified approximation to the transfer function of a given component is made analytically, and the simplification is usually so great that the resulting equations can be handled easily in multiloop analogue networks.

Still more information, however, is needed before the designer can attempt to synthesize a complete control system. The transport times of the various coolants and the various loops must be known. Plants can be laid out with many feet of pipe between major components, and the time delay in these pipes is an important part of the control system. Of particular need is the total coolant circulating time, the time the primary coolant is in the reactor, the time the primary coolant is in the heat exchanger, and the time the primary coolant is in the pipes.

MISCELLANEOUS PLANT INFORMATION

There are many miscellaneous bits of information which also must be considered before the control system can be synthesized. Some of these factors depend upon the type of main coolant system used. For example, in systems employing water or gas as the coolant, it usually will be found necessary to pressurize the main coolant system in order to obtain reasonable plant efficiency. Operating a loop under pressure calls for a complete pressurizing system including heaters and controls. These controls of necessity tie in with the controls of the main coolant system.

Another auxiliary system which directly affects the main system is provision of devices to take care of emergency electric-power failures. It may be desirable in some plants to provide auxiliary means of dumping power or employing elaborate fail-safe mechanisms.

A third item which affects the design is the type of coolant control permitted. If pumps or blowers are used to circulate the primary coolant, multiple-unit operation may be considered. Multispeed units, variable-speed units, or the switching of units on or off the line, are methods whereby coolant control may be achieved. One scheme may have a considerable advantage over another in a particular plant design.

Another factor is the auxiliary load which the plant must supply in addition to its primary output. In a nuclear power plant for a vessel, for example, a considerable hotel load exists separate from the prime task of driving propellers. It may be desirable also that most of the direct auxiliaries such as the pumps be tied to the nuclear-powered system.

The foregoing statement implies that a certain percentage of the auxiliary load must be furnished from a source other than the nuclear power plant. Just as the battery on an automobile is required to run certain of the automobile's auxiliaries, a given amount of nonnuclear power is usually necessary to start the plant and keep it in operation. To start the plant and its auxiliaries and to maintain them under given operating conditions usually will require a large amount of detailed electric switchgear. This apparatus, though complicated in its own right, is conventional in nature and usually is capable of supplying exactly what the control-system designer wants.

When all of these factors have been considered, the control-system designer then can synthesize the entire system. The problems of the designer now involve problems of components, particularly the limitations of the various components. These limitations usually lead to the separate protection circuits for each of the major components.

COMPONENT CHARACTERISTICS AND LIMITATIONS

Components such as the turbine, the heat exchanger, the reactor vessel, the pumps, and the reactor itself require the most study. As each plant will contain a different group of components with different limitations, only a few of the more obvious conventional characteristics and limitations of the plant will be mentioned in order that more emphasis may be placed on the reactor characteristics.

Of interest to the control designer are the heat-exchanger temperature limitations. The structural limitations of the heat exchanger probably will permit only certain

rates of change of temperature during both startup and shutdown operations. In other words, a heat exchanger may have a limitation stresswise such that the temperature of the coolant flowing through it may be permitted to change only by so many degrees per minute. A completely different rating, however, may be given the boiler for very short time transients. The same condition exists with respect to the reactor container. This container also will have stress limitations which will prevent any attempt to change coolant temperatures faster than a given rate.

Minor component limitations exist in the piping and the specific instrumentation of each component. Consideration of these limitations usually leads to the settings on the relief valves.

REACTOR NUCLEAR CHARACTERISTICS

IT NOW IS NECESSARY to examine roughly the various factors contained within the reactor itself which affect the over-all plant control. It has been shown[2] for control purposes that the reactor can be considered as a nonlinear device having an approximate transfer function of the form

$$K_r G_r(s) = \frac{K_r N_o}{s+a} \qquad (1)$$

where: K_r and a are constants, s is the LaPlace transform operator, and N_o is the neutron level at which the reactor is operating.

The problem of controlling a loop containing this component whose gain depends upon the level at which it operates has been given extensive study.[2,3] The ultimate objective of this study was to be able to specify components of a control system which would manipulate the nuclear control rods. In practice the nuclear characteristics of the reactor also are involved in the detailed rod-moving-mechanism design.

To the component designer the problem of rod-mechanism design is a simple one of merely asking how far a given control rod must move and how rapidly. These questions can be answered by the reactor designer who must determine first the total number of control rods required and where they are placed in the reactor. These answers are derived from heat-transfer considerations. He then must consider the problem of the effectiveness of these rods in changing the over-all reactivity of the reactor. He also must consider how this effectiveness changes during the lifetime of the reactor. The variation of these constants with time brings up for consideration again the kinetic relationships of the various poison build-ups and burn-outs in the reactor. Reactor fuel depletion must be considered again and the total amount of reactivity to be built into the reactor determined.

The next reactor consideration is that of the magnitudes of the various coefficients of reactivity. The temperature coefficient of reactivity has been mentioned previously and its absolute magnitude is necessary to enable the determination of the degree of stability of the primary loop. Another coefficient of reactivity may be determined for some reactors and this is a pressure coefficient. This term is defined in a manner similar to the temperature coefficient and consists of the amount the reactivity of the reactor changes, and in what direction, as the pressure of the coolant in the reactor changes.

Another nuclear constant of importance to the control designer is the so-called "mean neutron lifetime." This is the average time taken by a neutron in starting out at birth in fission and dying by creating another fission or being absorbed or lost in some other portion of the reactor. The importance of the mean neutron lifetime controlwise comes about in that it affects the constant a of equation 1.

Startup and shutdown reactor considerations call for knowing the amount of nonneutron power produced immediately after shutdown and the neutron level to which the reactor ultimately will drop after a prolonged shutdown. This information plus the information concerning the artificial source of neutrons placed in the reactor is necessary for proper nuclear instrument design. The nuclear instrument design considers these facts, the known instrument sensitivities, the neutron and gamma flux levels about the reactor, and the type of instrumentation philosophy required. This information is then filtered into the control system and the placement of the instruments and their operation in the control system determined.

CONCLUSION

MANY OF THE FACTORS INVOLVED in the control of a nuclear power plant have been mentioned and it is apparent that the operational requirements of the plant determine the control system in the same manner as in a conventional plant. It has been noted that the fact that a reactor is present in the system does not alter any of the conventional requirements. Rather it appears as though a given performance can be specified for the nuclear plant, and the reactor and all of its appurtenances can be tailored to fit the required output.

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Supercharged Steam Turbine-Generator

The first completely supercharged steam turbine-generator, now under construction at the Allis-Chalmers Manufacturing Company, is the latest and most important step in the history of size reduction of steam turbine-generators following the first use of supercharged cooling in the rotor of a 60,000-kw Allis-Chalmers generator installed in mid-1951.

In this design, cooled hydrogen is forced at high velocities through the conductors of both stator and rotor. The machine is being built for development and test purposes and will have a nominal rating of 40,000 kw and a 60,000-kw rating at increased hydrogen pressure.

Flashing of D-C Machines Caused by Short Circuits

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STUDIES MADE ON THE flashover characteristics of two d-c machines revealed in part the mechanism of flashover as a result of short circuits. Experimental data obtained from oscillographic records and from high-speed motion pictures substantiated the concepts of arcing currents and flashing currents as follows:

1. Arcing current is related to commutation and produces ions over the surface of the commutator.
2. Flashing current is in the opposite direction to arcing current.
3. Flashing results from the ionized film of gas that envelopes the commutator and is initiated where the brush-to-commutator voltage is high enough to sustain an arc with the ionized gases present.

The minimum time for flashing to occur after the initiation of a severe overload was found to be dependent upon the time required for a commutator segment to move from a brush of one polarity to the next brush of opposite polarity. Considerable randomness in time occurred for less severe conditions of flashing as shown in Figure 1.

The effect of operating conditions prior to short circuit were also determined. It was found that increasing the initial load increases the tendency of a generator to flash, or to be more specific, requires a reduction in the terminal voltage over that at no load if flashing is to be prevented. It should be noted, however, that the initial load condition results in a peak current that is higher than under the no-load condition. In contrast to this it was found that increasing the speed decreased the threshold value of terminal voltage and also decreased the magnitude of peak current.

An important factor in the flashing characteristics of a machine is the response of the interpole flux to the rapidly changing armature current. It is well known that the interpole flux is insufficient to give satisfactory commutation at high armature currents due to saturation effects. It is also of equal importance to realize that during high-current transients the interpole flux lags the change in current. This is illustrated in Figure 2. The lag in flux can be compensated, in part, by starting at full load where some interpole flux has been established. It was observed that under this condition higher values of short-circuit current were obtained before flashing occurred. The use of laminated interpoles in the machine, in place of the solid interpoles, resulted in a marked decrease in the time lag of interpole flux with respect to the transient armature current and decreased the susceptibility of the generator to flashover.

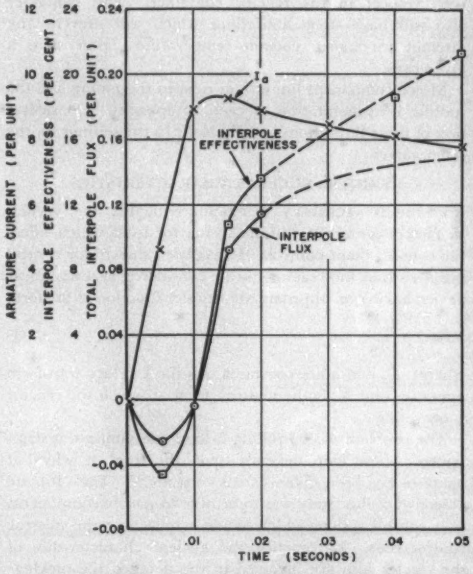

Figure 2. Interpole flux during transient armature current. Initial conditions: 250 volts, no load, 1,800 rpm, 90-horsepower motor operated as generator, solid iron interpoles

$$\textit{Interpole Effectiveness} = \frac{\textit{Actual Interpole Flux}}{\textit{Interpole Flux for Normal Commutation}}$$

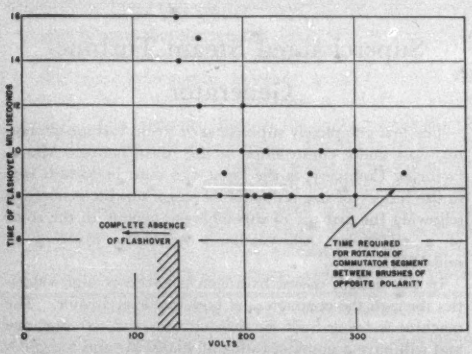
TIME OF FLASHOVER, MILLISECONDS
COMPLETE ABSENCE OF FLASHOVER
TIME REQUIRED FOR ROTATION OF COMMUTATOR SEGMENT BETWEEN BRUSHES OF OPPOSITE POLARITY
VOLTS

Figure 1. Flashing time of a 300-kw generator at 1,200 rpm

Digest of paper 53-86, "Flashing of D-C Machines Caused by Short Circuits," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Plastic Electrets and Their Applications

H. H. WIEDER SOL KAUFMAN

The electret effect in high polymer plastics is described and compared to published data on the behavior of wax electrets. The results indicate the existence of large ionic polarizations giving rise to an essentially constant external electric field. Some engineering applications of electrets are discussed and limitations presented in terms of current knowledge of electret phenomena.

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ALTHOUGH electrets made from carnauba wax have been the subject of considerable study,[1-12] relatively little attention had been devoted to electrets using radically different materials. In the hope of obtaining electrets with improved characteristics, an investigation was started on the nature of the electret effect in high polymer dielectrics. An attempt also was made to relate the behavior of plastic electrets to the observations and experiments made by others upon wax electrets; in addition some electret applications were examined in the light of materials and techniques presently available.

The electret is here defined as a dielectric which can maintain a sensibly permanent external electric field. Note that ferroelectrics such as the barium titanates could not be termed electrets for, although permanently polarized, they maintain only an internal electric field; nor would dielectrics which had been given surface charges which could be neutralized by water immersion or exposure to humid or highly ionized air be called electrets. Electrets, if treated in the foregoing manner, can recover their charges after being removed from the humid atmosphere or from the vicinity of the ionizing agent.

EXPERIMENTAL METHODS AND RESULTS

APPROXIMATELY 30 ELECTRETS using lucite, Plexiglas, and nylon have been prepared up to date. Preparation of an electret involves heating of the sample to a temperature in the neighborhood of its softening point while being subjected to a high-intensity electric field. The sample is allowed to remain in this state for several hours while it is being polarized and, if the polarization current is not masked by a too-high conduction current, it will have the typical behavior shown in Figure 1. After the total current has reached a stable state, the sample is allowed to cool rapidly to room temperature while still under the applied field. The forming temperatures for these samples is not critical. For lucite and Plexiglas it is in the vicinity of 150 degrees centigrade. For nylon it is in the neighborhood of 200 degrees centigrade. The conventional method of storage is to cover the active surfaces of the electret with a continuous conducting electrode, metal foil, or plates. This effectively short-circuits the external electric field and thus prevents neutralization of the surface charges due to external agents.

A measure of electret strength is set up by relating the external electric field to an effective surface charge density; the latter being measured by the principle of electrostatic induction. This technique has been covered in detail.[10-12]

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Subcommittee on Energy Sources of the Committee on Basic Sciences.

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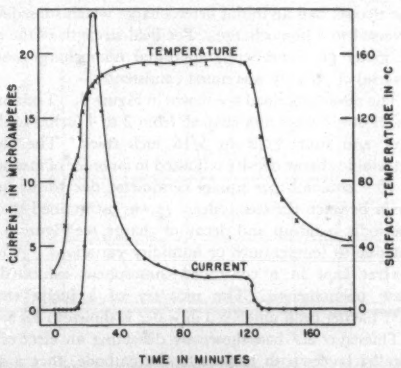


Figure 1. Total current versus time during formation of a Plexiglas electret

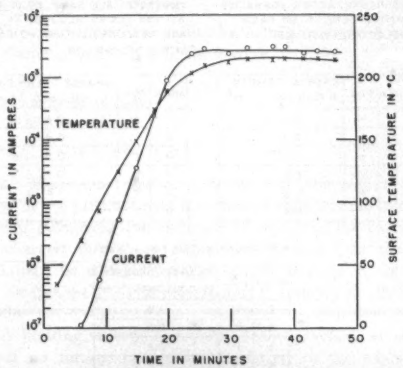


Figure 2. Total current versus time during formation of a nylon electret

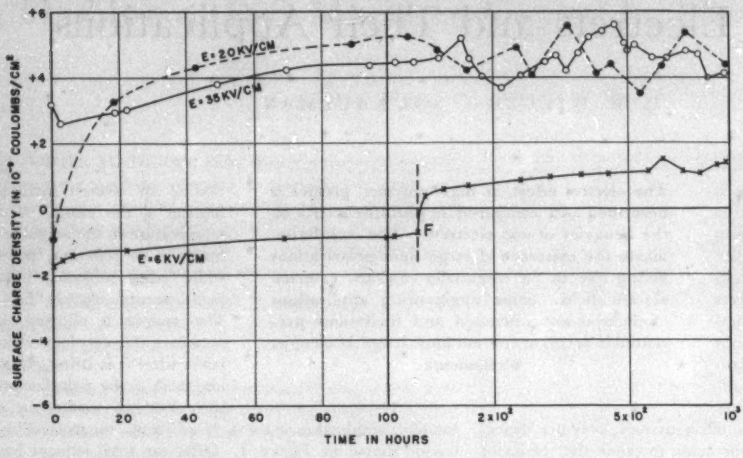


Figure 3. Surface charge density versus time for lucite electrets formed at a temperature of 150 degrees centigrade, using the indicated field strengths. At time t=F, and at 25 degrees centigrade a 50 kv per centimeter field was superimposed on the electret causing the sharp sign reversal

It can be shown that plastic electrets will behave during and after formation in a manner similar to wax electrets. Some disparities, however, do exist: lucite and Plexiglas electrets exhibit during formation the typical polarization current observed for carnauba wax during the heating and subsequent cooling cycle, see Figure 1. In the case of nylon, however, the formation current differs in shape because of a higher conduction current; this in turn masks any polarization current which might be present, see Figure 2.

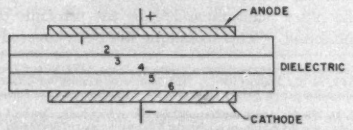
Lucite, Plexiglas, and nylon were successfully used in making electrets. Polystyrene, however, gave negative results. An attempt to polymerize the latter under the influence of a high-intensity electric field did not indicate any electret behavior.

Using the terminology employed by Gross[6-8,10] two distinct charge densities can be defined: if the polarity of the electret surface be the same as that of the applied potential during formation, the surface charge is termed a homocharge; conversely, if the polarity of the surface charge be opposite to that of the applied potential, it is termed a heterocharge. In the case of the experimental plastic electrets, if the forming field was below 6 kv per centimeter a slowly decaying heterocharge resulted. If the field strength was in the range of 20 to 25 kv per centimeter, the electret had an initial heterocharge which subsequently reversed to a homocharge. For field strength of the order of 35 kv per centimeter, an initial homocharge and no reversal of polarity was noted consistently.

The results obtained are shown in Figure 3. The samples under study were disk shaped, from 2 to 4 inches in diameter, and from 1/16 to 3/16 inch thick. The highest detectable charge density is limited to an order of magnitude of 10^{-9} coulomb per square centimeter due to air breakdown between the electrodes. It was ascertained that the aperiodic build-up and decay of charge, see Figure 3, was not due to temperature or humidity variations. A nylon electret kept in a controlled atmosphere exhibited the same phenomenon. The recovery of a lucite electret after having been immersed in water is shown in Figure 4.

Thiesen et al.[9] had shown by dissecting an electret into parallel layers with respect to the cathode, that a space charge exists within the wax electret. An attempt to do this with plastic electrets would have been difficult.

Table I. Charge Densities on the Respective Surface Areas of a Plexiglas Electret Prepared From Three Individual Sections and Formed as a Unit



0.5 HOURS AFTER FORMATION CHARGE DENSITY ON EACH DIELECTRIC SURFACE

AREA	POL.	CHARGE DENSITY IN COULOMBS/Cm^2
1	−	3.0
2	+	3.0
3	−	1.7
4	+	2.2
5	+	3.0
6	−	5.4

IMMERSED ALL SAMPLES IN WATER AT 0.55 HOURS ALLOWED TO DRY AND MEASURED AT 20 HOURS AFTER FORMATION.

AREA	POL.	CHARGE DENSITY IN COULOMBS/Cm^2
1	+	0.5
2	−	0.4
3	+	0.3
4	−	0.1
5	+	1.2
6	−	2.4

650 HOURS AFTER FORMATION

AREA	POL.	CHARGE DENSITY IN COULOMBS/Cm^2
1	+	1.6
2	−	0.4
3	+	0.8
4	−	1.1
5	+	2.2
6	−	5.1

An electret was prepared, however, in the following manner:

Three Plexiglas disks 4 inches in diameter and 1/32 inch thick were temporarily pressed into a single disk using a very thin layer of silicone grease between the disks in order to insure that they could be pried apart after being formed into a single electret. A field of $E=$ 23 kv per centimeter was impressed upon the dielectric at a forming temperature of 150 degrees centigrade, the sample being processed in the usual manner for electrets. Results are indicated in Table I. In a qualitative way these results tend to support the data obtained by Thiesen[9] and Jaeger[12] and their assertion as to the existence of a space charge within the electret.

Some conclusions as to the nature of the electret are possible on the basis of experimental results: since the process of growth of a simple polarized charge distribution is unlikely, it is reasonable to postulate, in agreement with Mikola[5] and Gross,[10] the existence of two separate decaying charge distributions of opposite polarities. A differential in their decay rates could result in the apparent growth of the total charge density in the direction of a greater homocharge. This growth is eventually limited and an approximate steady state reached because of air breakdown. Both polarized distributions involve the mechanism of ionic charge. The alternative possibility that dipole orientation is the basis of inner polarization is unreasonable since the maximum surface charge density obtainable in this way (assuming complete alignment with reasonable magnitudes for dipole moment and dipole density) is 5×10^{-6} coulomb per square centimeter. In contrast, the actual charge density due to inner polarization, heterocharge, computed by integrating the displacement current-time curve of Figure 1, is found to be 5×10^{-4} coulomb per square centimeter, assuming conductivity to be independent of time.

ELECTRET APPLICATIONS

An electret subjected to a rise in temperature will deliver a current to an external impedance connected to its electrodes; it will, however, be irreversibly discharged in the process.[6] It must be emphasized that in any other way an electret is not to be considered as an energy source.

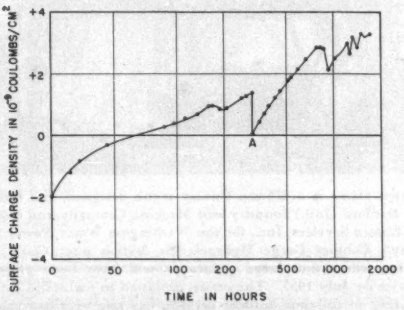


Figure 4. Surface charge density versus time for a lucite electret. Initial heterocharge, reversal to homocharge at 70 hours, recovery of homocharge after water immersion

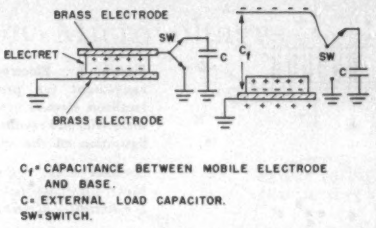


Figure 5. The electret as a high-potential–low-capacitance source

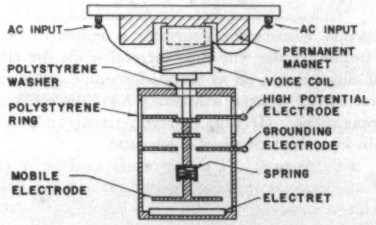


Figure 6. An electrostatic generator employing the external field of an electret

A number of applications utilizing the permanent electric field of the electret have been verified experimentally and are indicated in the following:

1. *High-Voltage (Low-Capacitance–High-Impedance) Source.* Starting with the upper electrode grounded then raised from the electret surface and subsequently connected to an external load, the induced charge is transferred to the external capacitor C. Figure 5 shows the operation of this circuit.

Obtained numerical values for a lucite sample 4 inches in diameter and 1/8 inch thick were

$Q=3\times10^{-7}$ coulomb
$C_f=20$ micromicrofarads
$C=30$ micromicrofarads

Since: $V=Q/C+C_f$, $V=6$ kv

2. *Electrostatic Voltage Generator.* If the value of C used in the previous case is increased considerably and the action of moving the electrode is repeated, the capacitor is charged through a cumulative process. At the beginning, the voltage increases almost linearly at the rate of $V=Q/C+C_f$. This corresponds to roughly $V=Q/C$ per cycle.

A limiting voltage is asymptotically reached, at which level no further charge is transferred to the capacitor. This limiting voltage is $V_m=Q/C_f$. For the foregoing values $V_m=15$ kv (providing breakdown does not occur).

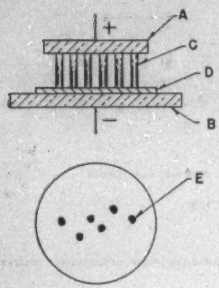


Figure 7. Electrode arrangement for producing localized electret areas in a dielectric, and resultant configuration of the electrets:

A = anode block; B = cathode block; C = cylindrical anodes; D = dielectric; E = electret area

A simple electrostatic generator is shown in Figure 6. It is important that the time interval while the electrode is left ungrounded be as short as possible, otherwise the electret surface charge will decay logarithmically after a few operations. (It will, however, recover if allowed to remain in a short-circuited condition.)

3. *A-C Generator.* If the external load be a resistor, then an electrode working against the electret field and executing harmonic motion will deliver an alternating current into the load. A qualitative experiment was performed using a lucite electret. The advantage of this type of operation is that no contacts or commutators are required (provided the load impedance is not too high).

Electrets also could be operated in push pull or in parallel thus increasing the total charge transferred to a load. Any other type of motion whether circular, impulse, or reciprocating, can be used to obtain an electrostatic generator by means of electrets. The electret is a very-high-impedance source. An experimental rotating electret generator was capable of delivering a continuous current of 10^{-7} ampere to a load which varied between 100 ohms and 100 megohms. Thus an electrostatic generator conceivably could be used as a high-impedance constant-current source.

4. *Electrostatic Memory.* By fashioning one of the electrodes as shown in Figure 7, localized areas of a dielectric can be made into an electret. Domains 1/4 inch in diameter and as close as 1/4 inch to each other may be made into electrets without polarizing the rest of the dielectric.

CONCLUSION

THE EXPERIMENTS OUTLINED in this article indicate that the mechanism of polarization is the same in high polymer dielectrics as in carnauba wax. Although the basic mechanisms of polarization are not completely determined, the work described tends to support the theories of Mikola and Gross, postulating, however, the idea that both the homocharge and the heterocharge are of an ionic nature.

The physical and chemical properties of dielectrics that would make suitable electrets remain largely undetermined. Two necessary conditions are, however, to be noted: the dielectric should have a resistivity of the order of 10^{14} ohm-centimeters, and the electret should have a softening temperature well above the ambient temperature at which it is stored.

It is the authors' belief that by using materials such as ceramics and glasses better physical and electrical properties could be obtained for electrets, and that by proper packaging and sealing these properties could be made independent of temperature and humidity thus opening a wider range of application.

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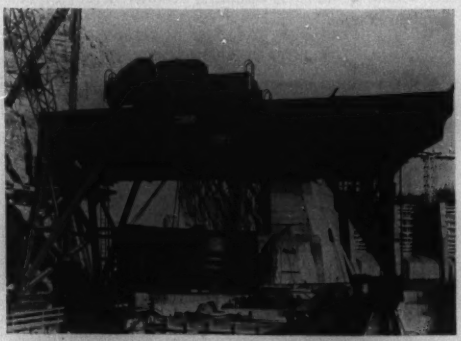
Crane for Turbine Service



Shown above is a 275-ton Gantry crane designed and built by the Bedford (Ind.) Foundry and Machine Company and installed by Ebasco Services, Inc., for the Washington Water Power Company's Cabinet Gorge Hydroelectric Station near Clark Fork, Idaho, where four large generators will have been placed in service by July 1953. The crane, designed to withstand extreme weather in full-time outdoor service, has safe overload capacity which enables it to handle the massive rotors weighing up to 330 tons each. It is intended for general service work over the turbine area

Accurate Radio-Frequency Microvoltages

M. C. SELBY

THE RADIO AND electronics field has been facing the problem of accuracy of radio-frequency microvoltages since sensitivity of radio receivers came into prominence as a competitive index of performance.

In searching for a source of accurate and reliable radio-frequency microvoltages the following basic requirements seemed indispensable or highly desirable:

(*a*). The output voltages of the source had to be known irrespective of loading conditions, that is, a constant-voltage source was necessary.

(*b*). Freedom of frequency corrections was essential at least over reasonable frequency ranges.

(*c*). A reliable, simple, and rugged physical construction with a very minimum of component parts was most desirable.

(*d*). The simplest and very minimum of calibration requirements were essential.

All of these requirements seem to be satisfactorily achieved with the new device briefly described and referred to here as a "Micropotentiometer." The equivalent circuit is that of a coaxial line shunted by a conductive film in a plane normal to the axis of the line, as shown in Figure 1. A source of radio-frequency energy supplies current to the Micropotentiometer section of the system through a coaxial line and the voltage output, V, from the Micropotentiometer, available across the annulus, is fed to the receiver. To a very good approximation, V is simply the product of the input line current entering the annulus and the d-c resistance of the annulus. This follows from the general field-theory treatment of the foregoing conductive annulus as a section of a coaxial line with an intrinsic impedance corresponding to that of the particular conductive medium. The absolute value of the transfer impedance, $|Z_m|$, of a transmission-line section, d-centimeters long, having a relatively high-conductive dielectric medium and a skin penetration, δ, is

$$|Z_m| = |R_m(1+j)(d/\delta)\ csch\ [(1+j)d/\delta]|$$
$$= R_m\left|1 - j\frac{d^2}{3\delta^2} - \frac{7}{90}\frac{d^4}{\delta^4} + \ldots\right|,$$

where R_m is the d-c resistance of the annular element.

Thus $|Z_m|$ is equal to R_m to better than 1 per cent for $d/\delta \leq 0.5$ and

$$V = I_1|Z_m| \cong I_1 R_m$$

where I_1 is the current entering the line section, that is, the annular resistor.

One of several variations of this device is shown in Figure 2. Agreement tests were conducted against a voltage-standardizing bolometer bridge and precision waveguide below cutoff attenuators. These tests indicated agreement well within over-all experimental errors, that is ±1 per cent to about 50 megacycles, ±3 per cent to 300 megacycles, and ±5 per cent to 900 megacycles.

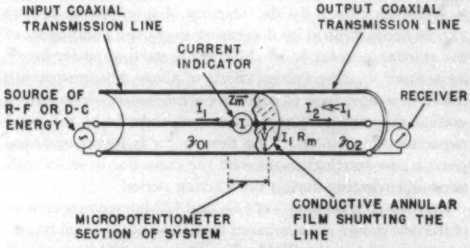


Figure 1. Equivalent circuit diagram of system employing a Micropotentiometer

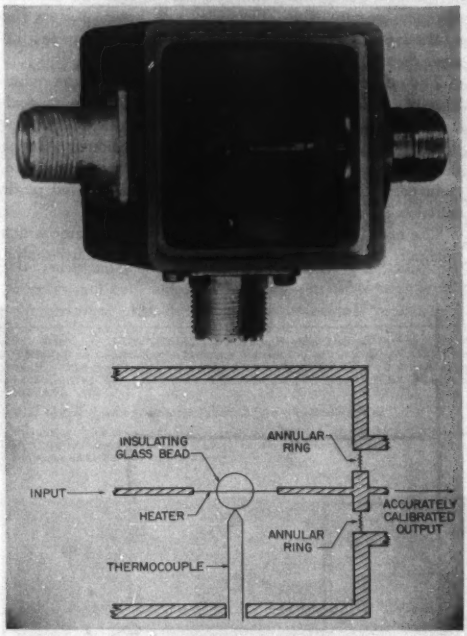


Figure 2. Micropotentiometer employing a thermoelement as a current indicator

Digest of paper 53-22, "Accurate Radio-Frequency Microvoltages," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Operations Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Single-Phase Motor Design to Minimize Voltage Dip

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A REDUCTION OF THE VOLTAGE DIPS and light flicker caused by the starting of single-phase motors can be accomplished by decreasing the power component of the starting current or by shifting the starting power factor to a more leading value. Both of these adjustments are made in a new type of capacitor-start motor which causes voltage dips only half as great as are produced by the usual capacitor-start motor. The new motor is larger and employs a new starting circuit with the capacitor in series with the main winding during the starting period.

Starting characteristics of 1/3- and 1/2-horsepower motors of the new design are compared with those of the usual capacitor-start motors in Table I. The new 1/2-horsepower motor has been built and tested. It has good accelerating torque and acceptable running performance. At full load the new designs have efficiencies and power factors two to three percentage points poorer than the usual capacitor-start motors.

The outstanding feature of the new designs is the reduction of starting power input while maintaining approximately the same starting torque. Three features of the new designs are responsible for the large reduction in starting power input. These features are increased rotor resistance, reduced auxiliary winding resistance, and improved phase splitting.

The new 1/2-horsepower motor is built in a frame which normally accomodates a 3/4-horsepower standard motor.

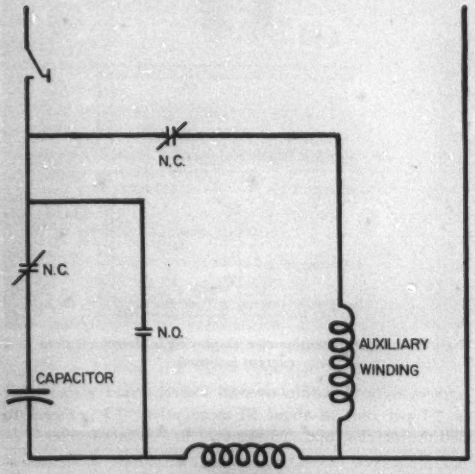

Figure 1. New starting circuit

Table I. Comparison of Starting Characteristics

	1/3-horsepower Motor		1/2-horsepower Motor	
	New Design	Standard Design	New Design	Standard Design
Torque (ounce-foot)	68.3	65.1	102	107
Current (amperes)	19.2	27.6	27.5	42.7
Power (watts)	1950	2845	2900	4580
Power Factor (per cent)	89.5	89.6	91.5	93.0
	I leads	I lags	I leads	I lags
Torque Efficiency (per cent)	56.0	36.6	56.3	37.4
Capacitor Size in Microfarads	316	260	416	430

Use of the same number of main winding turns as in the 3/4-horsepower motor permits a 60-per-cent increase of rotor resistance without excessive slip or running losses at 1/2-horsepower load. Total stator losses at start are reduced by a redistribution of stator copper. An 11-per-cent reduction in main winding copper permits a 37-per-cent increase in auxiliary winding copper. The starting circuit of Figure 1 is used. Auxiliary winding turns and capacitor size are selected to give the desired torque and nearly perfect phase splitting at start.

The power factor of the new motor is usually leading at start. If the desired starting torque is 450 per cent or less the best phase splitting is achieved with more auxiliary winding turns than main winding turns. The current in the main winding at start is larger than the current in the auxiliary winding and the total current leads the applied voltage.

The new motor has several disadvantages. Higher cost is the principal disadvantage of the new motor described in this article. If manufactured in as large quantities as the present capacitor-start motors the costs would be approximately 35 per cent higher. If manufactured in small numbers the costs would be very much higher.

The main winding current is conducted through a motor-switch contact all the time the motor is in operation; therefore, the probability of switch failure is greater than in the present capacitor-start motors.

The new starting circuit does not permit dual voltage ratings and is not practical for capacitor-run motors.

General adoption of the motor features described in this paper perhaps is not economical for the popular sizes of fractional-horsepower single-phase motors. These features, however, can be advantageously employed in the design of larger motors with low starting currents. A 3-horsepower 230-volt single-phase motor with 200-per-cent starting torque can be built with a starting current of 50 amperes at a power of 0.75 leading. The development of heat pumps and home air conditioners may bring a demand for larger single-phase motors with low starting current.

Digest of paper 53-141, "Design of Single-Phase Motors to Minimize Voltage Dips," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The XY Toll Ticketing System

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In order to bolster the decreasing net profits of independent telephone companies on short-distance toll calls, automatic toll switching equipment with automatic ticketing has been developed. The ticketing system temporarily stores data on a magnetic tape from which the information is printed as a toll ticket.

IN RECENT years independent telephone companies have become acutely aware of steadily decreasing net profits on short-distance toll call operation. The recording for billing purposes of certain information concerning the toll call has required the assistance of an operator. For this reason, manual toll switching has been retained in spite of the fact that mechanical systems for performing the actual switching functions have been available for many years. Fixed toll charges and rising labor costs have combined to make it extremely difficult for the operating companies to realize a profit on this phase of their business.

One solution to this problem is the granting of free service on these loss-producing toll lines. While this would prevent further losses, resulting increased traffic would create a demand for additional expensive plant equipment and personnel, which in turn would produce no revenue.

A second solution is the reduction of the number of people involved in producing the toll billing records known as "toll tickets," by the installation of automatic toll switching equipment incorporating automatic ticketing means. Several attempts have been made to provide such equipment and two basic types have emerged.

One, the verifying type, requires the calling subscriber to dial his own directory number before dialing the number of the desired station. The other, considerably more complex and expensive, is the identifying type wherein the calling station number is automatically found and recorded without effort on the part of the subscriber.[1] The system described herein is of the verifying type.

Any toll ticketing system, manual or automatic, must accomplish three things: 1. The information concerning the toll call must be recorded in some manner. 2. The recorded information must be translated and interpreted for use by the ticketing device. 3. The information must be presented finally in a readily usable form.

RECORDING THE INFORMATION

SINCE THE PRIMARY objective of any toll ticketing system is the reduction of manual labor in producing the toll tickets, the most desirable system would be the one which would reduce the labor factor to zero. In order to achieve such a goal, the designer is confronted with the need for an inexhaustible medium on which to store, temporarily, the billing information until that information is printed as a toll ticket. Several such storage devices are available, only one of which is economically sound.

The Recorder. The unique magnetic tape recorder shown in Figure 1*A* forms the heart of the *XY* Toll Ticketing System as the intermediate storage device. The tape in the magazine can record information concerning 100 average toll calls before it requires automatic interpreting equipment to print the tickets, simultaneously preparing it-

Full text of paper 53-184, "The XY Toll Ticketing System," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22-24, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The author wishes to acknowledge the contributions of F. A. Morris, J. D. Confeld, and H. S. Gleason to whom should be credited the major portion of the circuit and mechanical design of the *XY* Toll Ticketing System.

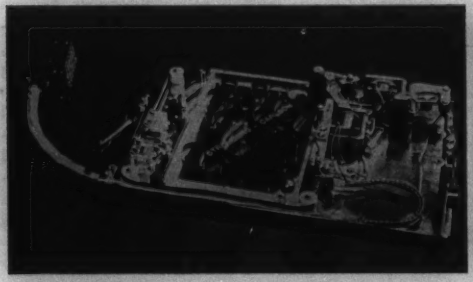

Figure 1A. The trunk recorder-reproducer which is used in the XY Toll Ticketing System. The magnetic tape in the magazine can record data on 100 average toll calls

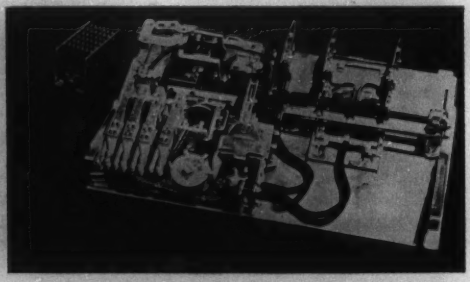

Figure 1B. The universal switch for use in any circuit in a step-by-step dial telephone system. Note the similarity of parts with the recorder-reproducer of Figure 1A

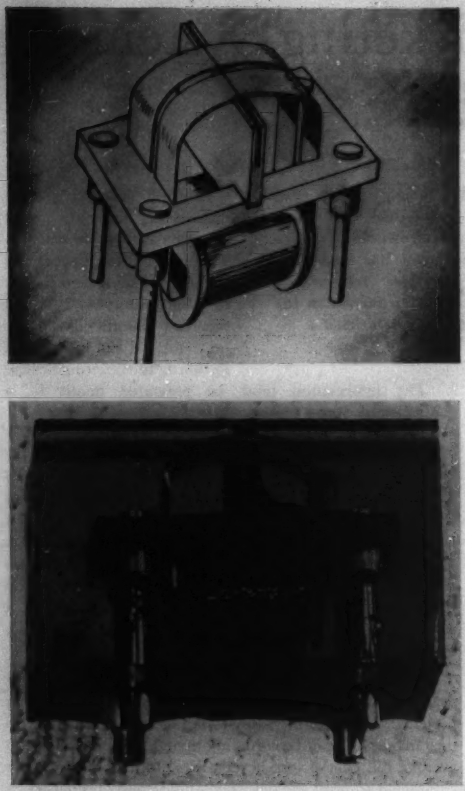

Figure 2. Above is shown the twin-track record-playback head before being molded in resin and below is shown the resin casting containing the head

self for reuse. One recorder is permanently associated with each toll trunk, operating completely unattended in all of its functions. The recorder records the calling and called subscribers' directory numbers, the duration of the call (elapsed time), the time of day, and the date.

Figure 1*B* shows the *XY* Switch manufactured by Stromberg-Carlson Company. This is a universal switch for use in any circuit in a step-by-step dial telephone system. Comparison with Figure 1*A* will show the similarity between the recorder and the switch. Great savings in tooling and manufacturing costs were achieved by using as many identical parts as possible in the two devices. Both are built on the same plate, use two of the same magnets, mount in the same way, and are jacked into the associated trunk relay equipment by means of identical cord and plug assemblies. Thus, the entire design of the *XY* Toll Ticketing equipment can be harmonious with standard *XY* switching equipment.

The recording is made on standard 1/4-inch magnetic tape. Approximately 30 feet of tape are contained in the magazine in the form of an endless loop. The tape is transported by a capstan which can be driven by either of two methods. For recording, the tape is advanced step by step in 0.057-inch increments by means of a ratchet drive. For playback, a clutch connects the capstan to a common motor shaft and the tape is driven at a constant rate of about 3 inches per second. The tape passes over a twin-track recording head and a double-width erase head. Felt-faced pads apply the necessary pressure to assure proper contact between the tape and the heads. Three contact springs, sensing two conductive areas applied to the back side of the tape, control the cycling of the recording and playback process.

The Tape Heads. Figure 2 shows the twin-track record-playback head before and after it has been cast in resin. Each head consists of a single 0.112-inch-wide lamination of molybdenum permalloy with a 1-mil gap spacer. The coils are 2,700 turns of Number *46* wire wound on a bobbin. The various parts are mutually supporting and interlocking. The erase head is built on the same principle, the lamination being 0.270 inch wide and its coil 50 turns of Number *27* wire.

The upper half of the twin-track head is energized by each dial impulse and makes a magnetic impression 0.002 inch wide on the upper half of the tape. The lower half of the head is energized upon release of the interdigit relay in the trunk circuit which also effects the advance of the tape by a single step. These interdigit pulses serve to separate the several groups of pulses derived from the dialed digits. The two series of pulses are known as "mark" and "space" pulses, respectively. To indicate the end of a call, mark and space pulses are recorded simultaneously when the trunk is released.

Block Diagram. Figure 3 shows a block diagram of the *XY* Toll Ticketing System, while Figure 4 shows the equipment itself, except for the trunk circuit. The digits of the subscriber's own number are used for two purposes. They are recorded in order to bill the call and they also set up a connection to verify the accuracy of the number dialed. If the call is verified, the verifying circuits are dropped off, and subsequent pulses (of the called number) are passed over the trunk to establish the connection to the distant subscriber. As soon as the called subscriber answers (answering supervision), the trunk transfers the recorder input to a common time impulse circuit, the minute pulser, transmitting one impulse per minute to the recorder during the conversation. When the calling subscriber hangs up (on-hook supervision), the trunk drops the linkage and transfers the input of the recorder to a common clock-calendar. Digital representation of the time of day and date is automatically pulsed into the recorder. Upon completion of this operation the trunk releases and causes an end-of-call signal to be recorded. The trunk and its associated recorder are then free to accept another call.

If the calling subscriber dials other than his own number the call will not be verified and subsequent pulses are neither recorded nor repeated to the distant office. This condition is indicated to the subscriber by means of a

suitable tone. Upon receiving on-hook supervision the trunk merely will enter an end-of-call signal and release. Similarly, in the case of "don't answer" and busy line calls, the trunk will enter an end-of-call signal—omitting the time and date information—and release. The presence of the date and time of day information is the criterion for the playback equipment to print a valid ticket. All abnormal calls are therefore ignored by the printing equipment.

Interpretation and Presentation. Common playback equipment attaches itself to each trunk recorder according to a prearranged schedule to permit common interpreting equipment to analyze the information recorded on the magnetic tape recorder. The interpreting equipment operates a ticket printer, common to all recorders, which prints a standard size toll ticket and automatically stacks these tickets, printing up to 10,000 per day. If complete automatic billing is desired, the information can be directed into a card-punching machine instead of the printer. In this case, 15,000 calls can be ticketed per day, since the card punch will operate somewhat faster than the printer.

Playback Control Circuit. Due to the large storage capacity of the trunk recorders, it is necessary and desirable to interpret the stored information only periodically—the period being determined by the toll traffic. Presumably, this would be once a day during a time of light traffic. The common clock-calendar unit is so wired that it will start playback at a predetermined time. The playback control circuit consists of a rotary switch and relays which function on a common equipment basis to augment the trunk during the playback cycle. The rotary switch acts as a trunk finder, stepping until the first idle trunk is found and associating the common control equipment upon seizing the trunk.

In the event that unusually heavy traffic conditions should cause a tape to become completely filled before the normal playback period, the normal schedule is ignored and the services of the playback control circuit requested at once. The rotary switch will advance directly to the full trunk and begin ticketing the calls from the recorder.

The "full" tape condition is sensed by the two conductive areas (foils) on the back of the tape. Should a subscriber seize the trunk and recorder just before the first foil is sensed, the recording of the data concerning the call will carry the tape past this point. Upon receiving on-hook supervision the trunk immediately busies itself out and calls for playback as described previously. A "safety zone" has been provided to take care of long conversations in this area. Should the subscriber pass the first foil and the conversation continue for 99 minutes, the second foil will be sensed, indicating an absolute "deadline." However, a super-safety area has been provided so that when the second foil

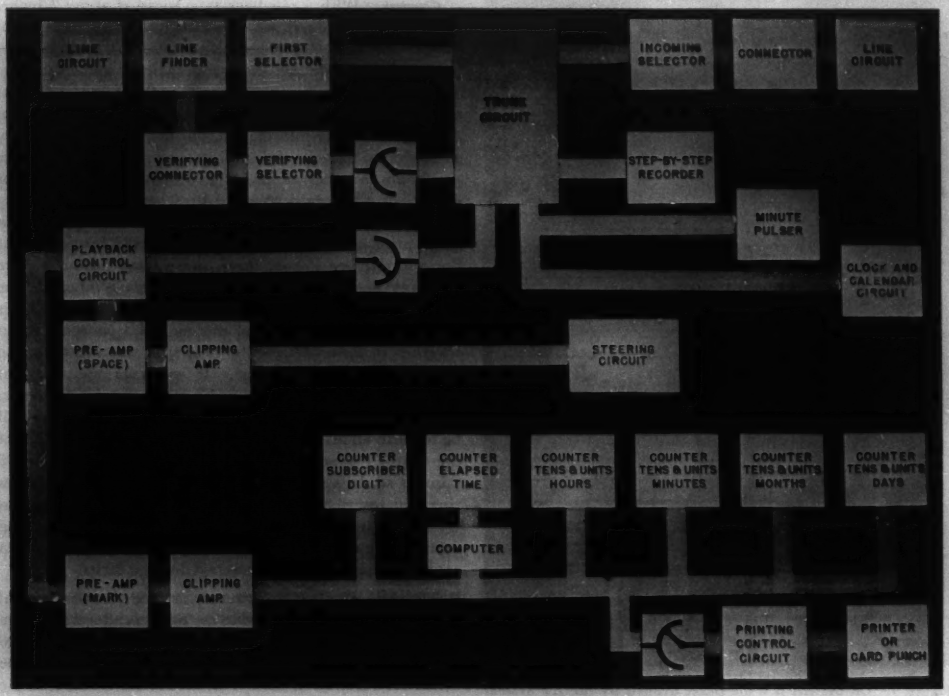

Figure 3. Block diagram of the XY Toll Ticketing System

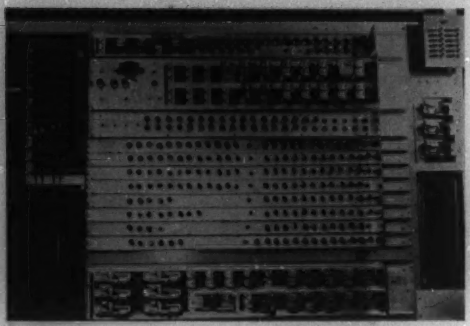

Figure 4. The equipment of the ticketing system without the recorders and the trunks

gives a forced disconnect, there still remains sufficient tape on which to record the date and time of day. If desired, the call can be continued by a manual operator rather than forcing disconnect.

Printing Control Circuit. The clutch of the recorder of the seized trunk is energized to move the tape to its "home" position. This is determined by the foil on the back of the tape. Control of the clutch is then transferred to the printing control circuit and the outputs of the twin record-playback head are connected to the mark and space preamplifiers. The recorder remains under the control of the printing control circuit until the tape has been completely played back and erased, whereupon the playback control circuit takes over once again. Before the trunk is released, a single reset signal is recorded for purposes to be discussed later.

Upon releasing the trunk the rotary switch advances and

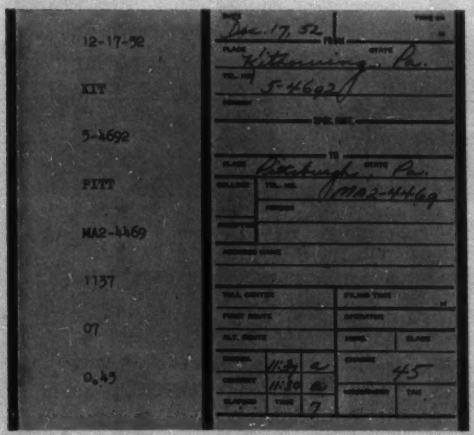

Figure 5. On the left is a toll ticket printed by the XY System which can be compared with a hand-written ticket on the right

associates the playback control circuit with the next idle trunk to repeat the playback process. After completing a search through all of the trunks the rotary switch will reach home and the playback control circuit normally will become inactive until the next scheduled start. After being amplified in the preamplifiers, the mark and space pulses are fed to the clipping amplifiers which further amplify the signals to a level suitable for driving the counting chains. The clipping amplifiers also act as marginal devices and will not transmit low-level signals resulting from interference. The signal pulses are shaped and brought to a uniform size by these amplifiers which have a very large range. Pulses having as little as 30 per cent of "standard" amplitude are transmitted and restored to full amplitude. The cutoff below that point is very rapid so that pulses only slightly less are completely eliminated. Pulses may be many times larger than standard and still be restored.

Steering Control Circuit. The function of the steering control circuit is to energize the proper circuits to count and store the recorded digits. When the steering control circuit is primed, it enables the first counter, which will count and store the first digit. Upon receiving a space pulse, the steering chain will be advanced to the next step enabling the second counter to count and store the second digit, and so forth. The steering chain will have as many stages as there are total digits of billing information.

Counters. With a playback tape speed of about 3 inches per second, the stored pulses are read off the tape at about 68 per second. Relay counting chains for counting and storing at this rate are extremely complex and expensive. Cold-cathode counting chains, on the other hand, can count very comfortably at this rate. One counting chain is used per digit of billing information, but the several chains vary somewhat in number of counting stages depending upon the maximum number of pulses expected. Those used for subscriber digits must count to 10, whereas those counting tens days, for instance, need count only to 3. Where a large number of pulses must be converted into a 2-digit decimal number (for example, the elapsed time can have as many as 99 pulses) there is no single symbol for the quantity 99 and it must be represented as two 9's. This is accomplished by connecting the ends of a counting chain together to form a "ring." This ring will represent the units digit of elapsed time. It will continue to count around, repeating as many times as necessary. However, for every time the units ring returns to zero, one pulse will be fed into an associated chain to represent the tens digit of the elapsed time. Thus, if 45 pulses, representing 45 minutes of elapsed time, are fed into the counter, the units ring will return to zero four times, thus stepping the tens chain to four and will stop on the fifth tube in the ring representing units digit five. This automatically converts a continuous series of pulses into two decimal digits.

Interpretation. The information stored in the several counters must be transferred to the ticket printer a digit at a time. By connecting the anodes of the counter tubes to the banks of the rotary switch it is possible to determine which tube is fired in each of the counters. Note that the information thus stored may be read, and the ticket printed,

in any order. A printed ticket is shown with a manually written ticket in Figure 5.

Due to the requirements of the ticket printer it is necessary to translate the decimal information into a permutation indicative of the numeral or letter to be printed. This translation is accomplished by a group of relays which are connected by the rotary switch to the anodes of the counter tubes. The ticket printer employs a 7-unit code so arranged that the operation of any single translating relay will result in printing a numeral. Combinations of two relays will result in printing a letter. The ticket printer and the printing control circuit are interlocked by the simple expedient of advancing the rotary switch by means of a pulse transmitted from a cam in the ticket printer.

Some of the information on the toll tickets is determined by means other than recorded data. The names of both the originating and called offices are determined by the operation of relays under the control of the playback control circuit which puts the proper letter codes on the proper terminals of the rotary switch banks. Likewise, the digits representing the year are strapped on the proper bank terminals. Information needed by the printer, such as carriage return, line space, ejection, and so forth, is strapped in.

The printing control circuit acts to correlate the functions of the playback control, steering, counters, and printing control circuit. Included in the printing control are the "destination code" relays which determine what trunk is being ticketed and thus control what office letters are printed on the ticket. These same relays are also used to adjust the computer for the proper base time and base rate.

The printing and playback control circuits are carefully interlocked so that playback cannot proceed unless the counters are in a receptive condition nor can control by the printing control be relinquished until the information is completely interpreted. To make certain that the counters do not contain any information left over from previous ticketing or other interference the playback control transmits a reset signal each time a new trunk is seized. As an additional precaution a reset signal is also recorded at the beginning of each tape as mentioned earlier. The reset signal is simply an end-of-call recording, which, when not preceded by normal ticketing information, serves to restore all of the counting chains to the starting condition. After the two safety resets the counters receive and store the call information, storing all information about one call before any other action takes place.

THE COMPUTER

The computer makes use of the elapsed time and destination code information to derive the charge for the call. It too uses cold-cathode counting chains to calculate the charge. Essentially, there are two chains and two rings. One chain counts off the minimum time for the particular call, the number of stages in the chain being adjusted by the destination code relays. If the call is based on a 3-minute period, for example, there will be three stages in the chain.

The first ring counts off the number of 5-cent increments (since all short-haul charges increase at the rate of five cents per minute), the second ring counts the 10-cent increments and the second chain counts the dollars.

The minimum charge is primed into these counters by means of the destination code relays. If the call is based on 15 cents minimum charge, the 5-cent tube and the number 1 10-cent tube will be primed and the charging will start at that point.

The elapsed time pulses are fed into the computer which at first counts them in the minimum-time chain. When the end of this chain is reached, the remaining pulses are diverted into the first money ring which will add five cents for each additional minute, the total being kept by the remaining two counters. The calculated charge is read by wiring the anodes of the counters to the rotary switch just as the other numerical information in the counters.

Figure 6. The ticket printer consisting of an electric typewriter and a "translator" to make it respond to an electric control

THE TICKET PRINTER

The basic mechanism of the ticket printer shown in Figure 6 is an electric typewriter to which the Commercial Controls Company adds what is known as a "translator" to make it respond to electric control. Essentially, the translator is much the same as the selecting mechanism in a Teletype machine.

For the *XY* Toll Ticketing System the ticket printer is further modified to the extent of adding a device for feeding

roll paper into it and converting the continuous roll into individual tickets neatly stacked.

The paper rolls are sufficient for 10,000 tickets, the paper being standard toll-ticket width. It is fed to the platen through guide channels, and after passing around the platen and being printed, it passes through another guide channel to a solenoid-operated chopping knife. After being cut off the ticket is ejected into a stacking hopper.

The only power required for recording the toll call information is the normal office battery at 48 volts direct current. For playing back and ticketing, 110-volt a-c power is needed. The anode voltage for the cold-cathode tubes is derived from a simple 500-milliampere 150-volt d-c power supply.

CONCLUSIONS

THE *XY* Toll Ticketing System meets the needs of the small- and medium-size telephone companies in their endeavor to solve the problem of decreasing profits in short-distance toll operation. By combining three basic arts—mechanical switching, magnetic recording, and electronics—the tickets for the toll calls are prepared in any desired form completely without manual attention, thus reducing to a minimum the high labor cost involved in toll billing. The 100-call capacity of the recorders and the 48-volt d-c recording operation prevent loss of revenue during a-c power failures. The use of cold-cathode tubes in the majority of the electronic circuits precludes the frequent changing of tubes since their life depends only on the number of on-off operations to which they are subjected. The *RCA-5823* tubes used have a life of approximately 40 million operations, a life equivalent to that of most of the other components of the system.

REFERENCE

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The Electric System Reliability Required in Petroleum Refining

E. R. FELTON

The reliability required for critical operations is discussed together with some of the design factors which affect this reliability. It is suggested that the automatic secondary selective system, as described here, offers the most economical and generally satisfactory service for critical process units in a petroleum refinery.

THERE IS A definite trend in the oil-refining industry toward large continuous-process units. This trend is being reflected in the industry's electric systems through the demand that they be able to furnish an uninterrupted, reliable source of power for these processes. Electric system failures result in production losses in any industry, but they can be particularly costly in the oil-refining industry because of the close interrelation of most of the continuous-processing units.

The reliability required for process units is determined on the basis of whether the unit is classed as critical or noncritical to the over-all refinery operation as well as the actual operating characteristics of the unit.

CLASSIFICATION OF PROCESS UNITS

SOME REFINERY UNITS are tied together through a processing chain where the satisfactory operation of one depends on the continuous operation of another. An example is a crude-oil distillation unit or "pipe still." This is normally the beginning of the refining procedure where crude oil is continuously separated into various components which are sent to other units for further refining. A short interruption or upset in this process adversely affects other units by changing the quality or quantity of their feed streams and it may take considerable time to re-establish normal operation. For the purposes of electrical design such units are classed as critical and their distribution systems are designed accordingly. The reliability of the distribution system or, in other words, the time required for electrical fault correction, is extremely critical in keeping all the units involved operating without costly production losses. Other units that fall in this category are the cracking units, debutanizing and splitting units, gas compression units, and so forth.

An example of a unit considered noncritical from the electrical design viewpoint is the grease plant. Stored materials are placed in a kettle for a "1-batch" operation. A power failure during the process means at most lost production for the one unit only and the product may or may not be lost. "Time of fault correction" or reliability,

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is comparatively noncritical because lost production usually can be made up by later use of spare manufacturing capacity or accelerating the operation. The same reasoning may apply to such refinery operations as blending and loading products, the manufacture of wax, and the chemical-treating plants.

ELECTRIC SYSTEM FOR CRITICAL UNITS

As stated before, the electric distribution system for critical units requires maximum reliability or a minimum time for fault correction. At Baton Rouge it has been concluded that a dual primary, automatic secondary selective system offers the required reliability for a minimum investment. This system is shown in Figure 1. Some of the advantages offered by this type of system are: 1. Faults are isolated and service restored automatically to the unit. No time is lost waiting for personnel to locate a fault and restore service by manual switching; 2. The simplicity of the design makes the application of automatic controls relatively easy; 3. Preventive maintenance is simplified; 4. Normal and spare machines can be split between busses so a complete set of machines is available from a single transformer bus.

The outstanding advantage is the isolation of faults and the automatic restoration of service. Some of the design problems that require proper engineering to achieve this are: 1. Adequate transformer size; 2. The undervoltage protection of motors; 3. Overcurrent protection of equipment; 4. Over-all co-ordination of relays and protective devices.

An improper solution to any one of these problems destroys the reliability of the system. A short discussion of each will show its importance.

DESIGN PROBLEMS

Transformer Size. For an automatic system to be effective, the transfer must be made without tripping out any of the loads. This requires that the transformers be of sufficient size to reaccelerate at least half of the operating motors in a reasonable time without dropping the bus voltage below the minimum "hold-in" voltage of magnetic motor starters. The controlling factor is generally the hold-in voltage and a value of 85 per cent is now considered a minimum.

In many cases designing for this minimum voltage gives excessively large transformer ratings well above that which is required for the total continuous load. Field tests and operating experience will show whether this minimum voltage can be safely reduced to 75 or 80 per cent to obtain better utilization of the equipment.

Undervoltage Protection of Motors. One

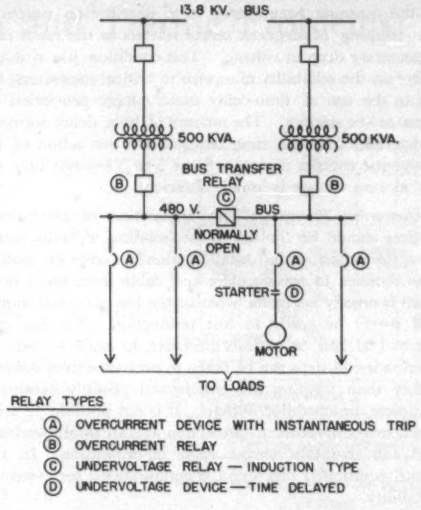

Figure 1. Typical single-line diagram for a critical process unit

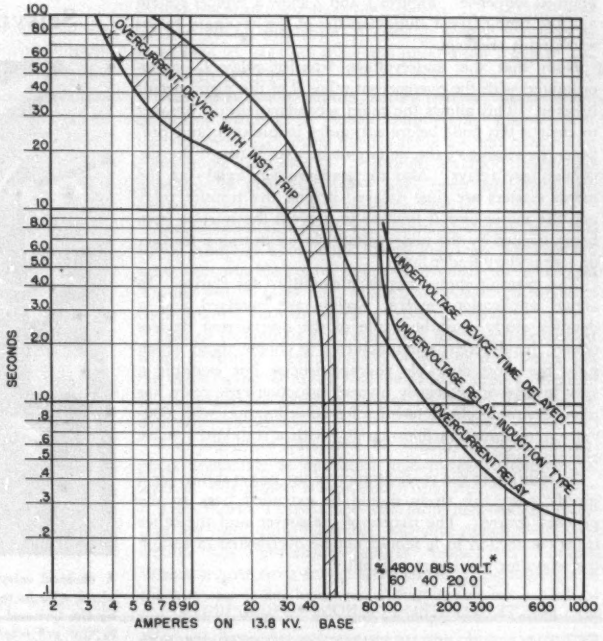
SECONDS
OVERCURRENT DEVICE WITH INST. TRIP
UNDERVOLTAGE DEVICE-TIME DELAYED
UNDERVOLTAGE RELAY-INDUCTION TYPE
OVERCURRENT RELAY
% 480V. BUS VOLT.*
AMPERES ON 13.8 KV. BASE
* BUS VOLTAGE BASED ON Zsource + Ztransformer = 7.4% ON A 500 KVA BASE

Figure 2. Typical relay co-ordination for a critical process unit

of the common occurrences in a distribution system is the tripping of magnetic motor starters as the result of a momentary drop in voltage. This condition has a major effect on the reliability of service to critical units and has led to the use of time-delay undervoltage protection for these motor starters. The amount of time delay normally is determined by the time required for the action of the automatic transfer devices. Some 2 to 3 seconds time delay at zero voltage is usually sufficient.

Overcurrent Protection. The application of overcurrent devices should be limited to the isolation of faults rather than protection against small overloads, except on motors. The damage to transformers and cable from small overloads is usually negligible whereas the loss of several motors will surely be costly in lost production. For example, thermal alarms on transformers can be used to indicate overloads and steps can be taken to prevent serious damage rather than tripping the circuit and possibly causing a complete, unscheduled outage. It is not possible, in some cases, to get overcurrent protection against small overloads and still maintain proper relay co-ordination. In this event, equipment protection is compromised for increased reliability.

Co-ordination of Relays and Protective Devices. To isolate faults with a minimum interruption in service, it is essential that all protective devices be co-ordinated to operate in a planned sequence. Figures 1 and 2 show a typical system and the time-current characteristics of the necessary relays and circuit breakers.

Note that the undervoltage transfer relay *C* is co-ordinated with the overcurrent relay *B* of the main circuit breaker. This allows the main secondary circuit breaker to clear a bus fault before a transfer is initiated, and prevents the closing of the tie circuit breaker through the use of auxiliary relays. Also the undervoltage relays at the motor starters are time delayed behind the transfer relay and the motor circuit breaker to prevent the starters from being tripped by the undervoltage device during a transfer or a secondary feeder fault.

The example shown has been simplified for clarity. In actual application, several circuits are involved and a detailed study must be made of the overcurrent devices offered by different manufacturers to choose those which have the most desirable characteristics. For example a very inverse or extremely inverse induction-type relay has more desirable characteristics for co-ordination with 600-volt circuit breakers than a relay with a standard inverse characteristic.

In addition to the co-ordination of the relays shown for a specific case, this study should be extended back to the primary source. The nature of the source and the other loads connection to it should not be overlooked in setting the relays for maximum reliability.

ELECTRIC SYSTEM FOR NONCRITICAL UNITS

THE ELECTRIC SYSTEM RELIABILITY required for noncritical units varies in degree according to how much production is lost at the one unit if an electrical failure occurs. These systems range from simple straight radial systems to manually transferred secondary selective stations and each has a proper application within its own limitations.

PRIMARY DISTRIBUTION SYSTEM

THE RELIABILITY OF THE secondary distribution systems can be no better than the primary distribution system at best. The primary system supplies both critical and noncritical units alike and must be designed for maximum reliability. This design depends on whether the refinery buys or generates its own power and no specific rules can be presented to cover all the acceptable systems possible.

CONCLUSIONS

THE IMPORTANCE OF a reliable source of power to refinery process units cannot be overemphasized. Good judgment on the part of the electrical engineer in choosing the right type of electric system for each process unit and then properly designing it may be the difference between lost production and continuous refinery operation. It is believed that, for critical process units in a petroleum refinery, the automatic secondary selective system, incorporating the features discussed, presents the most satisfactory and economical answer to the problem.

Selsyns Aid "3-D" Projection

A chained selsyn keeps this motion picture projector synchronized with its mate for 3-dimensional projection. Manufactured by the General Electric Company, the selsyn generator is linked to the projector motor by chain and sprockets. The selsyns are powered by an a-c wall plug and are interconnected between the cameras by wall- or floor-mounted wires. Changing from 3-dimensional to standard feature projection is accomplished by merely snapping a wall switch

Studies of Impulse Strength and Testing Problems

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AN EXTENSIVE INVESTIGATION was made covering (1) study of the surge characteristics of windings, (2) determination of the impulse breakdown of insulations, and (3) development of methods for demonstrating insulation levels.

Previous work on alternating and direct voltage endurance of machine insulation was correlated to impulse strength of machine insulation.

Impulse testing conditions were studied on a calculating board and on simulated windings. This study was extended to actual machine windings where low-voltage repetitive surges were applied. A single-turn winding was tested at high voltage wherein 13.8-kv insulation was demonstrated to possess an impulse level in excess of 50 kv.

In the tests the windings were separated at the neutral and the voltage distribution differs from that obtained in service with the windings connected together at the neutral. The following summarizes pertinent observations:

1. The maximum voltage observed in a winding with an ungrounded end terminal may be twice that encountered when the end terminal is grounded.
2. It is possible that seriously distorted voltage distributions may occur within the winding during impulse testing, depending upon the impedance of the terminating resistance.
3. The resultant voltages and oscillations are predictable by calculation-board studies employing lumped constants as the phenomena are similar to those which occur on short transmission lines.
4. The impulse voltage distribution can be predetermined at low voltage on the actual winding by employing repetitive surge testing equipment.
5. Overvoltages during impulse testing due to reflections and oscillations may be avoided through suitable control of test conditions.
6. The wavefront of the incoming test surge voltage should be suitably sloped. The 10-microsecond-front wave appears to be acceptable for test.
7. During impulse tests, the winding should be terminated through a resistance which is reasonably close to the surge impedance of the winding in order to limit the maximum voltage within the winding to the level of the applied voltage.
8. Single-turn coil windings, when terminated in the proper impedance, will withstand impulse voltages 1.25 times the peak of the proved insulation strength of the gound wall.

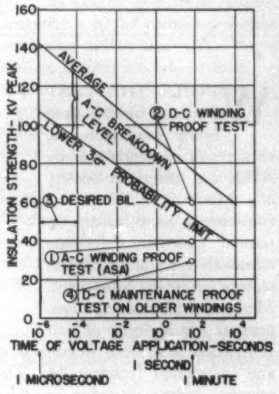

Figure 1. A graphic representation of insulation co-ordination factors for 13.8-kv machines

Recently accumulated test data as to the voltage endurance characteristics of mica insulations used on high-voltage generator windings indicate that the impulse level for the ground insulation of such generator windings is more than 25 per cent above the peak of the 1-minute 60-cycle ASA proof test.

The use of d-c 1-minute factory tests on high-voltage generator windings at values considerably higher than the suggested 1.25 times the 1-minute a-c test peak value gives ample assurance of the impulse level for the ground insulation of generators (that have been so tested) to ensure co-ordination with surge protection.

Studies of impulse voltage distributions on simulated and actual windings have demonstrated that large high-voltage generator windings with single-turn coils can withstand impulse test voltages high enough to provide assurance of co-ordination with the level of protective devices.

Testing techniques and equipment have been developed which permit predetermination of voltage distribution on the actual winding at low voltage so as to prevent damage to the generator winding due to unforeseen reflected or oscillatory voltages.

The procedure developed for single-turn windings appears applicable to multiturn high-voltage windings and work on this project is now under way.

The industry's experience with large high-voltage windings has been quite favorable, as conventional surge protection has prevented failures from overpotentials. Where failures from surges have come to the attention of the authors, it has been found that there were contributing causes (such as previous damage to the insulation). From this it can be concluded that the present surge protection practices of the industry are satisfactory, and that the currently used insulations possess adequate impulse levels for the type of surge protection used.

Digest of paper 53-11, "Studies of Impulse Strength and Impulse Testing Problems on High-Voltage Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Principles of Load Allocation Among Generating Units

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The various factors that should control the assignment of generation among power units of a power system are assembled and reviewed briefly here. Whether to use a unit and at what load can be determined satisfactorily only by co-ordinating availabilities and costs of other units, total system load, and interconnection schedules, together with electrical limitations such as spinning reserve, service continuity, voltage regulation, and transmission losses.

WITHIN THE LAST 3 years turbine and boiler manufacturers, as a result of suggestions by AIEE and American Society of Mechanical Engineers committees, have made extensive tests to determine allowable rates of generation change on steam equipment. Methods of determining transmission loss in terms of unit generation have been developed and are being improved and simplified continually. The need for adequate reactive reserve is being recognized, including requirements as to diversity in location and flexibility of control. Telemeters and other fast-acting recorders have permitted continuous totalization of system load and a better appreciation of maximum normal rate of system load change. The universal use of telemetering and load control on interconnected systems has led to a better understanding of the conditions of assignment of generation which provide the most effective balancing with system load requirements.

CURRENT OPERATING PROBLEMS

THERE ARE STILL several items on which more information is needed. It is still not known whether maintenance cost or liability to sudden failure are increased if a unit is operated continuously at wide open throttle. It is not known in any particular case how far, if at all, the manufacturer's factors of safety can be safely encroached on by temporarily increasing steam pressure above rating. There is little information available on the over-all incremental efficiency of boiler, turbogenerator, and auxiliaries at loads between nominal name-plate rating and maximum capability. In fact, there is no generally accepted definition of maximum capability. There is almost no information as to the effect on efficiency of either large or small output variations about a given average output as compared with continuous operation at the same output.

FUEL COST

IT GOES WITHOUT SAYING that one of the major factors controlling the most desirable allocation of generation between units is the total cost of power. The unit cost in cents per kilowatt-hour is a product of plant efficiency as measured in fuel Btu per kilowatt-hour combined with the unit fuel cost in cents per million Btu. Neither of these two factors is as simple as it sounds. It is generally known that when more than one unit is involved incremental rather than average efficiency must be considered, and that minimum over-all cost is obtained when each unit is working at the same incremental cost. It is not so well understood that incremental costs apply only to steady output conditions. There are few test data available on the cost of changing load rapidly across a narrow band as compared with operating at steady load in the middle of the band. Incremental loading theory is based on sustained load following changes and neglects thermal losses or gains during the change process. Tests of both narrow-band and wide-band cycling are needed to compare with fixed output conditions. There is little information about the additional heat losses in building up to a steady output or in backing down from a steady output. Such losses may be important when a large unit's output is changed once a day or oftener as compared with the old practice of base-loading it except on week ends.

The incremental fuel efficiency of most modern turbines decreases slightly with load until a point near the nominal name-plate rating, above which it decreases rapidly. The efficiency of most units at maximum capability is several per cent below the guaranteed value at nominal full load. The boiler efficiency generally is lowered slightly at high loads. Percentage of station use decreases as the load increases. The result is that the average station has a reduction in incremental efficiency as load increases.

It is becoming generally understood that the total cost of power delivered to customers is the proper criterion rather than the total cost of power at the power plants. If distribution losses are not affected by plant loading, the delivered cost is composed of three controllable factors:

1. Fuel cost at power plant.
2. Other costs at power plants.
3. Transmission loss.

Item 1 is well understood. It is usually obtained on a gross basis, and it must be converted to net by proper measurement of station use. This is easy in modern unit-type plants. Item 2 consists of labor and supplies for operation and maintenance. Incremental nonfuel operat-

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ing costs are usually estimated averages. Incremental maintenance costs are usually approximated or neglected. Information on item 3 is available in current technical data.

Methods are now available for combining fuel cost and transmission loss and determining by network analyzer study or by computing devices, the minimum cost of power delivered at a substation for any reasonable number of combinations of generator availability. A fuel and loss co-ordination study gives a means of minimizing with some assurance the delivered total cost of energy instead of working as heretofore with a very rough approximation, namely the unit cost of energy at the generating plants.

REGULATING REQUIREMENTS

THE PRIMARY REQUIREMENT of a power system is not to operate the plants at the lowest cost but to generate at each moment the exact amount of power required by the customers. That particular amount should be generated at the lowest cost, other things being equal. However, other things are never equal. Service, voltage, and control considerations affect both over-all system costs and over-all system revenues.

The growth of systems and of interconnections may conceal temporarily the penalties for not "matching" load and generation. As the system or interconnected group becomes larger, frequency deviations will be smaller but harder to correct. If the group is large enough, there will be no apparent change in frequency for ordinary unbalances in any one system between load and generation. In such cases it is necessary to look at the net interchange over all tie lines to see whether a system is taking care of its own obligations. Interconnection does not obviate or reduce the necessity of each system taking care of its own load changes by its own plants, or of making technically feasible and financially sound arrangements for help in regulation. Interconnection reduces the required percentage of spinning reserve, but does not eliminate the necessity of carrying spinning reserve.

An important danger in parallel operation arises from the ease with which any system can avoid its responsibility for carrying its own load, by generation or by firm contract, by spreading this burden among many unsuspecting neighbors; this will result in poor frequency, erratic tie-line loading, reduced tie-line capability, lowered fuel economy, and wastage of hydroelectric energy. This hazard should be avoided by proper contractual and technical arrangements for transferring either regulation or a block of capacity in those cases where comparative energy costs and/or location of capability justifies such transfer. In such cases the two systems involved require special control facilities and practices. There may be some question as to whether any system should buy its regulation from a neighboring system, unless the two systems have mutually inducive financial arrangements, co-ordinated planning, ties of adequate capacity, and a reliable high-speed channel for net interchange load control. Experience in some areas has shown that the claimed savings are offset in part by technical difficulties and policy differences.

At times of rapid normal load change on a system, such as in the early morning and at noon, the continuous matching of load and generation is not easy, even if there were no economic or technical limitations in the power plants. There is no over-all combination of telemetering, load control, and governing which will reproduce a change in tie-line loading instantly and exactly in turbine output. The main source of nonlinearity is in the turbine governor and in the synchronizing motor which drives it. Some improvements in both of these devices have been made in recent years. Sooner or later there probably will have to be provided linearity by means of a feedback system, as is done in other types of control.

The rate of instantaneous load change is not easy to measure even under normal conditions. The amount of change over several minutes is not too difficult to measure, but for shorter intervals the rate probably varies inversely as the square root of the time interval.

There are fundamentally two different types of customer load changes which must be handled. These types of load change are

1. *Sustained Load Changes.* This type of load change occurs over a period of minutes and when not properly controlled shows up the net interchange chart as a drift away from the scheduled value. This type of change has long been recognized and has been handled satisfactorily with impulse-type telemetering and impulse-type load control. This type of control recently has been developed to a point where it can be utilized by the dispatcher to follow the desired system loading schedule by setting dials in the dispatcher's office, provided he knows the desired generation on each station for each value of system generation.

2. *Fringe Load Change.* This type of load change is not sustained and exists for a minute or so at the most. It is this type of load which causes the characteristic bandwidth on most ties. When this band is of sufficient width to limit the amount of power transfer over the ties, these fringe load changes must be reduced by corresponding generation changes even though they cannot be eliminated entirely. Since the fringe load control must be very fast in its detection of the start of a swing, it cannot be of the impulse type but must be continuous. Similarly the telemetering that transmits this intelligence to the control must be of the continuous type. Consequently, telemetering and control are not separate problems but only different phases of the same problem, necessitating close co-ordination of the two.

3. *Combination Load Changes.* From the over-all operating viewpoint of any one system on which both types of load changes occur, the dispatcher should be able to assign definite percentages of each control response to various stations. For example, one operating requirement might be to maintain constant integrated output of the steam plants over a period of time but to utilize their ability to respond rapidly to fringe load changes. This would be done by the dispatcher setting zero percentage of the control action for absorbing integrated load change but a high percentage of the control action for correcting

fringe load changes. Another practical requirement might be to have the steam plants absorb the sustained load swings while rapid load changes are assigned to hydro stations. The hydro stations then would maintain constant integrated output as might be desired to maintain minimum stream flow, but would respond rapidly to the short-time fringe load swings.

The preferred modern means of getting speed and uniformity of response from system generation is to send the regulating signal to as many stations and units as possible, limited only by the cost of the control channels or the small size of the units involved.

Limitations on the speed of response of steam equipment probably will continue to exist, but these limitations are not as serious as formerly. Until recently the manufacturers had little data on the effects of differential temperature changes on steam turbines. Long ago they set a limit of 1,000 kw per minute with the implication that still slower changes or no changes at all contributed to the reliability and life of the turbine. Recently the manufacturers have found that more rapid changes are permissible and in some cases desirable. The manufacturers now have revised their instruction books for the newer units, permitting a 25-per-cent instantaneous load change after the unit has been on the line long enough to attain normal temperatures.

In a power system operation of any single unit without regard to system requirements may have serious effects on the performance of the system as a whole. The ideal system would have a small and controllable normal margin of operating reserve in every item.

The regulating problem today is primarily one of system operation rather than one of equipment design. Operation at maximum turbine capability usually means that the boiler or some of its accessories are operating wide open, leaving no adjustment to meet normal variations in fuel or weather conditions. A turbine operating wide open is not responsive to system speed drop. Its governor operation is almost negligible, thus forcing other units on the systems to carry the entire burden of regulating frequency or tie-line loading. The response of a single unit varies greatly from one valve point to another, but if several units are used simultaneously for regulation the response is more uniform and approaches the average governor slope. The foregoing are some of the reasons why operation of a turbogenerator continuously at maximum capability increases the cost of other power sources and decreases quality of service.

RESERVE

In addition to the reserve required for regulation, a certain amount will be needed for emergencies. Kilowatt reserve always is regarded as essential. Its location is not too important unless the system has transmission bottlenecks. In some cases kilowatt reserve may be purchased from another interconnected system.

Reactive reserve is a much more serious problem. Generator capability is sometimes limited by availyble transformer taps or by excitation. The system power factor varies seasonally and tends to drop as the system grows, unless offset by capacitor installations. For these reasons considerable margin in reactive capability is desirable. Excess reactive capability provides about the only margin available to the dispatcher to meet system emergencies, such as line or generator failures. This margin should not be used up in normal operation. Some margin of easily available reactive kilovolt-amperes is desirable, not only on the power system as a whole but in each area—unlike kilowatt reserve, reactive reserve cannot be supplied effectively from interconnections or from remote sources. Reactive losses in transmission are three to eight times as great as power losses. Therefore each load center needs a controllable reactive source at hand or nearby. For this reason, generators normally should not be loaded to full kilovar capability values.

CAPABILITY

The nominal name-plate rating of a unit in the past had been established largely for the convenience of the manufacturer and the planning engineer, and it has been found to have little bearing on operation.

The operating department needs two capability ratings. One is the normal capability which safely can be carried continually under ordinary operating conditions. The other is the emergency capability. Both of these must be determined by test and will include both electrical and mechanical limitations in generator, turbine, boiler, fans, pumps, and exciter, as effective under annual peak conditions of power factor, weather, and maintenance needs and schedules.

There has been considerable difference between various definitions of maximum capability. In some cases this has been the maximum-hour output of record. In other cases maximum capability has been an ideal figure for the operators to aim at, even if seldom obtainable in practice. There is now a growing tendency to define maximum capability as something that can be depended upon under the worst weather and system conditions which reasonably may be expected. Such a rating will be considerably in excess of name-plate rating, but it will be less than the maximum capability as determined by test under favorable conditions.

It is not easy to agree on "the worst conditions which reasonably may be expected." Owners, planners, designers, load dispatchers, statisticians, and others may like to set a plant's capability at the highest possible figure. The plant superintendent may like to have a little cushion in capability to fall back on to facilitate normal maintenance, or to allow for inevitable wear, poor fuel quality, high temperature of cooling water, low system frequency, and so forth. He does not want to utilize regularly certain emergency measures which are of only temporary value and perhaps hazardous and expensive, such as raising steam pressure above guarantee, restricting interstage extraction, shutting down coal crushers, and so forth. Such measures should be reserved for extreme emergencies of short duration. The main difficulty in setting emergency ratings seems to be that the plant and the dispatching groups do not take each other into their confidence. Any

station supervisor could understand what happens to a power system in case of extreme emergency, if the dispatcher would tell him, and would admit that such emergencies require team work—and team work requires instant understanding and co-operation by all concerned. There is a problem for top management when the system operator and the station supervisor view each other with mutual suspicion.

One solution to the maximum capability problem may be to use a range of figures, covering both favorable and unfavorable conditions. An intermediate figure might be agreed upon for normal forecasting and scheduling of operation. It seems that any figures adopted should be established primarily for operating purposes even though they may not agree with those required by Defense Electric Power Administration, Edison Electric Institute, Federal Power Commission, the State Commissions, the Boards of Directors, and others (compiled by their own rules). Very recently, there has been some agreement on the following definition, as applicable to many utility requirements:

Station capability shall be normal maximum net generation for one hour, measured at generator voltage, obtainable when plant is consuming the usual fuel, with usual steam conditions and normal interstage extraction from turbine, using all turbine and boiler equipment that is maintained in operating condition, and with such equipment in normal state of maintenance and cleanliness, when generators are operating at normal voltage, with operating power factor on the generators as normally imposed by the system, this capability to be as determined at time of seasonal peak on the system.

CONCLUSIONS

MANY ELECTRICAL AND mechanical considerations have to be reconciled in scheduling system generation. The plant supervisor should be responsible for determining availability, minimum loads, maximum loads, permissible rates of output change, efficiencies, fuel costs, and other technical problems of operation and maintenance. Whether to use a unit and at what load can be determined satisfactorily only by the load dispatcher considering availabilities and costs of other units, total system load, interconnection schedules, and various electrical limitations including spinning reserve, service continuity, voltage regulation, and transmission losses. This co-ordination cannot be accomplished by giving control of one of these factors to a separate department. The load dispatcher should dispatch the load, not just operate the transmission switches.

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Integration of Bad-Weather Landing Aids Recommended by ICAO

Ways to improve co-ordination of the varied radio, radar, and visual aids used to help pilots land safely in bad weather have been recommended by an air navigation conference held in Montreal, Quebec, Canada, by the International Civil Aviation Organization (ICAO), an agency of the United Nations.

Technicians representing 25 nations and 4 international organizations spent 4 weeks examining as a related group many individual air navigation problems in the fields of air traffic control, aircraft operation, meteorology, bad-weather landing aids, and communications.

The conference was described by the chairman, G. J. Warcup of the United Kingdom, as a "new type of technical forum designed to knock away the partitions between some of the pigeonholes of aviation techniques."

Reviewing the conference, Mr. Warcup said: "There can be little doubt that the experiment proved a success. This was evidenced, for example, by recommendations made on the integration of bad-weather landing aids such as high-intensity approach lighting systems, radar systems, and electronic blind-landing devices."

The integrated study was made possible by the joint efforts of experts from many widely differing technical fields.

The ICAO conference devised a new and simplified version of in-flight reporting which permits plain language transmission without requiring the pilot to use complex coding processes.

The conference examined the problem of landing aircraft under poor visibility conditions with an acceptable degree of regularity. It recommended certain improvements in the location and adjustment of elements of the instrument landing system. It also provided for a better co-ordination of radio, radar, and visual aids.

The use of radar in air traffic control is still in its experimental stages. The conference defined the air traffic control requirements for radar equipment and discussed the technical aspects of different types of radar systems. The purpose of using radar for air traffic services is to provide greater flexibility in directing the movements of aircraft thereby expediting landings and take-offs.

Other actions included further development of the ICAO instrument-approach-to-land procedures, agreement on a standard holding pattern for aircraft awaiting their turn to land, and study of visibility at airports.

Operation Problems of Air-Turbine Accessory Drives

T. E. ABRAHAM

The air-turbine motor is a highly significant and necessary advancement in methods of accessory drive. As it is in the developmental stage, there are many problems involved in its use and they probably will increase in number. However, it provides an important means of decreasing aircraft weight and complexity.

THE RECENT development of the air turbine as a means of aircraft accessory drive has provoked the controversy which often accompanies any change in established methods. On one side there is a tendency to proclaim the air turbine as a cure-all for the problems involved in obtaining accessory power. On the other, it has been condemned on the basis of inefficiency and the difficulty it presents in obtaining satisfactory operation under some flight conditions. The latter viewpoint may have been fostered in part by recent studies in which the air turbine was considered to drive only a single generator and did not include all the advantages obtained by this means of accessory drive.

This article is a presentation of experiences to date with an air-turbine drive; the reasons for selecting an air turbine over other methods of drive; problems encountered in selection, and the methods of solution of these problems. The object of this discussion is to aid the engineer in obtaining a realistic view of the air-turbine motor as a method of accessory drive.

ADVANTAGE OF THE AIR-TURBINE DRIVE

AS A RESULT OF the increasing emphasis on the battle against weight, the electrical engineer is called on to supply more and more power out of each pound of airplane weight charged to him. The major step which can be taken in this direction is the use of a controlled-speed mechanism to drive the power-generating equipment allowing much closer design of this equipment and making available the functional advantages of controlled-frequency alternating current. The problem is not one of using this power but of producing it, and thus the solution lies not alone with the electrical engineer but also with the mechanical engineer. It is the latter who must provide a means of generator drive which will maintain the frequency within sufficiently narrow limits to allow optimum design of electric equipment and components.

Until recently, there have been two basic methods available for obtaining constant frequency: (1) the motor-generator or inverter, and (2) the hydraulic transmission driving from the engine accessory-gear train. With the advent of the jet engine and the attendant availability of high-pressure air from the engine compressor, a third method of constant-speed accessory drive became apparent: the air-turbine motor.

Accessory drive accommodations on the engine are inherently compromised by the necessity of maintaining engine interchangeability between air frames. In order to provide for this interchangeability, the number of drive pads and their power requirements will be designed to satisfy a maximum and will thus place a weight penalty on those air frames not requiring this maximum. The air turbine, as a separate piece of equipment, avoids this weight penalty as it may be tailored to fit each aircraft model's requirements. This does not necessarily mean a complete new design in each case. The tailoring will probably be confined to the gear train and to speed changes of the turbine wheel.

In a multiengined aircraft, the air turbine may be placed close to the load center of the airplane thus eliminating the main power transmission lines normally running from the engines to the fuselage. This not only results in a major weight saving and in localization of service troubles, but can result, because of the high cost of designing, developing, and installing electric and hydraulic lines, in a substantial saving in system cost. Somewhat offsetting this is the fact that an air duct must be provided from the engine to the unit; but, as the existing air-conditioning ducting may be used, with slight enlargement, the penalty is generally small.

One of the recent studies of the use of air-turbine drives has been made on the basis of supplying electric power only and presents a very pessimistic outlook for the drive unit from the weight standpoint. Actually, in the investigations discussed herein, the main weight advantage was accrued through the use of the turbine to drive the airplane hydraulic pumps. The reason for this lies in the

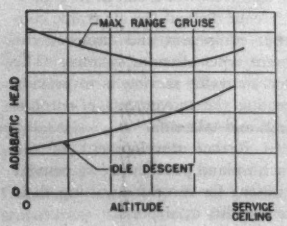

Figure 1. Bleed-air-power availability for two critical flight conditions

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elimination of the engine-to-fuselage distribution lines which were of large size because of the length of run and the low temperatures at which the system had to operate.

An evaluation of the installation weights and the effect on engine performance with the accompanying fuel penalty for the constant-speed hydraulic drive and the air-turbine drive showed a weight advantage for air-turbine drive of approximately 75 pounds.

VARIABLES AFFECTING TURBINE POWER OUTPUT

SINCE THE AIR TURBINE DERIVES its power through the expansion of air bled from the engine compressor, the maximum power output is a function of the power available per pound of compressor bleed air. This has been termed adiabatic head and is the power which can be extracted from the air at 100-per-cent air-turbine efficiency. As it is a function of the compressor-bleed-air pressure and temperature, which are directly related to engine thrust, the adiabatic head will vary with the engine thrust condition. Since it gives a measure of available power, the adiabatic head is one of the primary parameters used in setting the design point of an air-turbine motor. Typical curves of adiabatic head for the two flight conditions of cruise and idle descent are shown in Figure 1.

The second parameter fundamental in determining the power available at the accessory drive pad is the efficiency of the turbine itself. A typical curve of the variation of the efficiency with the pressure ratio is shown in Figure 2. The characteristic shape of this curve is a slight negative slope above the optimum design point and a sharp drop off to zero below this maximum. This drop off is caused by the fact that the exit velocity from the nozzles is approaching the effective wheel speed. Thus the efficiency curve may be shifted by changing the operating speed of the turbine.

It is obviously desirable to set the turbine to operate at maximum efficiency during cruise. The degree to which this is attainable is limited by the power requirements at the lower pressure ratios. If a drive unit is designed to give maximum efficiency for long-range cruise operation, it can be seen in Figures 1 and 2 that the power availability will be markedly decreased under conditions of idle descent and, more important, landing approach. If a landing approach is considered in which the throttle is held in an idle-stop position, the maximum power obtainable from the drive unit will vary with airplane speed and with drive unit speed as shown in Figure 3.

It has been stated in a previous paragraph that the air-turbine power will be a function of the engine power. Thus the turbine output may be raised by increasing the idle setting, as shown in Figure 4. Also, since the engine power is markedly affected by the ambient temperature conditions, the power available from the air turbine also will vary with ambient temperatures. Figure 5 compares the maximum output at temperatures of −67, +60, and +100 degrees Fahrenheit.

One of the major problems in the design of an air turbine is that of providing power at the low-pressure ratios available when the airplane is descending from high altitude with the engines throttled back to idle. The importance

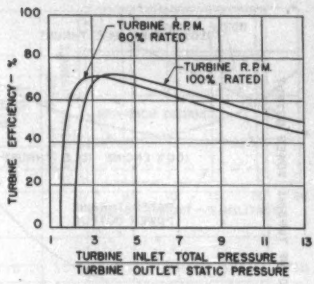

Figure 2. Turbine efficiency as a function of pressure ratio

of this flight condition as a basic design criterion is determined by the idling schedule of the engine. The idling schedules initially presented for some of the advanced engines were such as to make the idle descent the basic design limitation for the air turbine. It has been found recently, however, that in order to alleviate engine operational problems such as flame-out, the altitude-idling schedule had to be greatly increased over the original estimates. Thus the idle descent from altitude is not the critical design point as initially thought. This is demonstrated in Figure 6, which shows the power available as a function of per cent frequency with varying altitudes for the condition of stall speed with engines idling. The trend here is definitely toward better frequency control as the altitude is increased; and, for the case in question, points up the landing approach as the critical flight condition involving an idling engine.

DETERMINING THE POWER REQUIREMENTS

IN SETTING UP THE power requirement schedule, the engineer should avoid the pitfall of attempting to provide drive power to supply the airplane needs with all equipment operating simultaneously in all flight and ground conditions. Much of the equipment has an intermittent duty schedule and the improbability of these items operating at one time must be considered.

In the selection of an air-turbine-drive unit, it is mandatory that a realistic approach be made in the determination of the power requirements. In general, there are four basic conditions which must be examined. These are

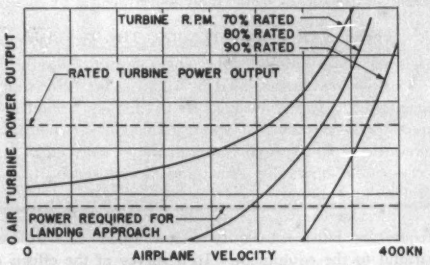

Figure 3. Effect of turbine speed on power output with engines idling

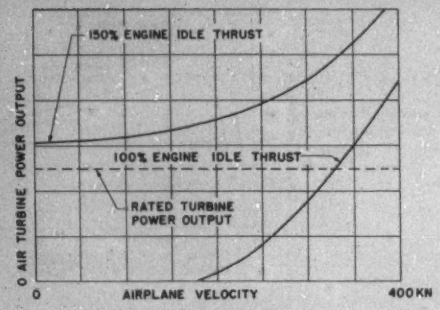

Figure 4. Effect of engine idle thrust on power output: 80-per-cent rated air-turbine rpm

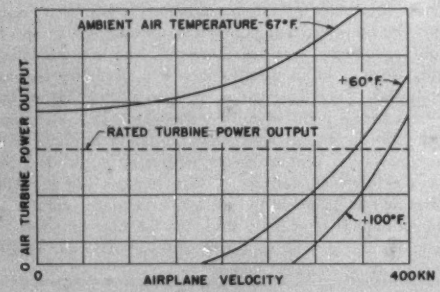

Figure 5. Effect of ambient air temperature on air-turbine power output: 80-per-cent air-turbine rpm engines idling

cruise, combat, descent, and ground operation. For a typical case, the power as a per cent of available accessory output (rating) ran approximately 40 per cent for cruise, 85 per cent for combat, 30 per cent for letdown and landing. The allowance that must be made for growth of power requirements is another factor which must be taken into account in the selection of an air-turbine motor. This is a factor which must be evaluated in terms of the requirements of the services and in accordance with the experience of the air-frame manufacturer.

EFFECTS OF UNDERSPEEDING THE TURBINE

As shown in Figure 3, the power output of the turbine can be greatly increased by allowing the drive unit to underspeed. The allowable speed reduction is dependent upon the effects of that speed reduction on the driven accessories. In hydraulic equipment the only effect is to increase the operating time, and is not detrimental to airplane operation.

In the case of electric equipment, however, operation at frequencies either above or below rated can be very harmful to the equipment. In a survey of the effects on various items of electronic equipment used on a particular airplane, it was found that the a-c electric motors examined were operable over a fairly wide frequency band. To cite an example, the variation of current with frequency for the electric-driven fuel pump tested is shown in Figure 7 and shows approximately 80-per-cent current increase when the frequency is dropped to 75-per-cent rated. It was felt by the motor manufacturer that the heating caused by this increased current would not be harmful for the short period of time required for operation at this condition.

It should be noted that the foregoing discussion presupposes the existing prevalent control system in which the voltage is held constant while the frequency is allowed to vary. The adverse effects on the motors caused by underfrequency operation can be alleviated, in most cases, by allowing the voltage to vary with the frequency. This, however, is unsatisfactory as it entails an additional system to supply equipment requiring constant voltage.

Of the electric equipment examined, the items which were found to demand the closest frequency control were those entailing the use of transformers. Equipment of this type generally may be classified in the two categories of instruments and communications. For one specific piece of communication equipment, it was found that operation below 380 cycles was hazardous even for the short times that would be encountered during landing approach. Figure 3 demonstrates that a reduction in frequency to about 300 cycles per second is required in order to insure adequate power from the air-drive units during approach.

Therefore, although most of the articles examined could tolerate a substantial frequency reduction for short periods,

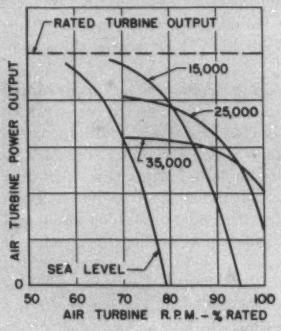

Figure 6. Effect of altitude on air-turbine power availability: engine thrust 150 per cent normal idle

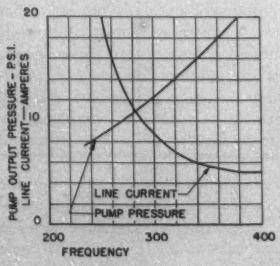

Figure 7. Effect of frequency on current for an a-c fuel pump operating at low fuel flow. Frequency is in cycles per second

the limitations imposed by the communications equipment precluded the use of turbine underspeed as a means of obtaining power at low-pressure ratios.

SOLUTIONS TO PROBLEM OF EQUIPMENT DAMAGE AT LOW FREQUENCIES

IT IS POSSIBLE THAT those components which are seriously affected at low frequencies could be redesigned to eliminate this characteristic. This loses the main advantage of controlled frequency since it entails a large increase in component weight. In all probability it would destroy interchangeability, as each manufacturer would desire that the components be tailored to meet his limits.

A second method of obtaining power at low-pressure ratios is the use of design compromises in the air turbine. Figure 2 shows the effect of changing the wheel speed of the turbine. Note that although the power availability at low-pressure ratios is greatly increased, the point of maximum efficiency is shifted so that it no longer coincides with the pressure ratios incurred in cruising. Also, the basic size of the turbine itself must be increased in order to maintain the required output of the unit, thereby greatly increasing the weight.

Another method of obtaining the same results, is by the use of a gear shift which would allow the use of lower turbine wheel speeds for the landing approach condition. The disadvantage of this method lies mainly in the increased complexity of the unit and control system.

By far the simplest solution to the problem is landing at an increased throttle setting which holds up speed but causes an increase of thrust on the airplane. This increases the adiabatic head available to the turbine and thus turbine output. Whether the increased thrust can be tolerated is a function of the airplane flight characteristics. A summary of the approach parameters of a given airplane as a function of engine thrust is presented in Figure 8. This demonstrates that the thrust which can be tolerated on landing is fairly high for this airplane; an increase of the idle thrust from zero to 15 per cent military results in an increase in approach distance for 1,000 feet decrease in elevation of 50 per cent. In this respect some classes of military aircraft enjoy a definite advantage in that the effects of increased throttle setting can be more than offset by the use of speed or dive brakes.

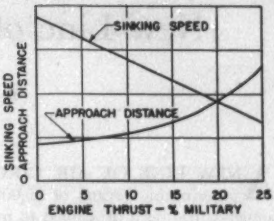

Figure 8. Effect of engine thrust on airplane approach parameters

In the latter method, the effect on wheel-brake wear should be examined. As the required increased idle thrust is generally more than that required for taxiing the airplane, the brakes will be used continuously during taxi to control speed. Examination of a particular example showed that with an idle setting of 20 per cent of military rated thrust, 90 miles of taxi distance at 40 miles per hour was the equivalent to 100 rated energy stops. Since the advanced thrust requirement is considerably less than the foregoing, it was felt that the increased brake wear was of little consequence.

Thus, the air-turbine motor is neither panacea nor pitfall but is a highly significant and necessary advancement in methods of accessory drive in the development stage. As such, the problems attendant to its selection and use are probably just beginning. It is not a piece of equipment which will find application in every air frame; but it does provide the aircraft engineer with a powerful weapon in his never ceasing battle against airplane weight and complexity.

Automatic Welding Machine Makes 62 Simultaneous Welds

A new automatic welding machine, just put into operation at the Irving Subway Grating Company, Long Island City, N. Y., does the work of dozens of human welders in a single stroke. It makes 62 simultaneous welds, or a total of 744 per minute. This represents 24 square feet of welded grating a minute, or 1,500 square feet an hour. The process is completely controlled by instrumentation by a single operator.

During the multiwelding process, pressure for forging the bearing bars with the cross bars is equivalent to 100 tons. Welding temperature is approximately 2,000 degrees Fahrenheit. The machine has its own water tower, with self-circulating system, for cooling transformers and conductors. Some 400 gallons of water per minute are used in the machine.

Welds can be made at desired spacing points for grating openings of different sizes.

Giant welding machine is started in operation by grandson of founder of Irving Subway Grating Company, while his father and grandfather (left) stand by

New Line of Low-Voltage Air Circuit Breakers

B. S. BEALL, III
MEMBER AIEE

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MEMBER AIEE

A NEW LINE OF AIR CIRCUIT breakers, having interrupting ratings of 50,000, 75,000, and 100,000 amperes, has been developed to meet the requirements of modern low-voltage electric systems.

Three frame sizes of the new line of breakers with electrical operating mechanism and equipped for drawout mounting are shown in Figure 1. These breakers have new short-time ratings and close-and-latch ratings, which are equal to the interrupting ratings. All three of these breakers have the same height and same depth dimensions and vary only in width. The 1,600-ampere size is designed also with a manual closing mechanism.

The multislot interrupters used on these low-voltage breakers interrupt the arc by dividing the current into multiple parallel arcs and by lengthening and cooling the arcs in narrow slots formed by perforated separating plates of phosphoasbestos. This efficient type of interrupter gives effective utilization of space and breakers of reduced size.

The design gives easy access for maintenance as the breaker can be separated into two parts, mechanism and back frame, without disturbing any control wiring or mechanism adjustments. The back frame has individually insulated poles, with multiple contacts for each phase. A new type of linkage maintains a fixed relationship between the moving arcing contacts and the main contacts, which is not affected by short-circuit stresses. The stationary contacts are spring loaded and located so that the magnetic force from short circuits increases the contact pressure. These design features are important in obtaining improved short-time and closing ability.

The electrically operated circuit breakers are equipped with a stored energy closing mechanism having the required closing ability which is independent of continuity of the control power source. In addition, the control power requirements have been reduced to a practical minimum and for the largest breaker 4 amperes at 115 volts, 60 cycles alternating current is required. Through a system of reduction gears and over-running ring gears, a small universal motor charges the closing spring with all the energy required in the closing operation. Release of the closing force is accomplished by running the charging cam over dead center, which produces an arcing contact speed of approximately 10 feet per second. Although the mechanism must develop sufficient force to close against short-circuit currents, its design gives retardation and partial recharge of closing springs under no-load operation. After the breaker closes and the control closing switch is released, the motor recharges the springs for the next closing operation.

There are two types of overcurrent trip devices. A series coil device is used for the 1,600-ampere frame which is interchangeable for ratings between 15 and 1,600 amperes. For higher ratings, 2,000 to 4,000 amperes, a magnetic structure is placed around the breaker stud, which constitutes a single turn coil for operation of the timing elements. Each type is available as a 3-element 2-armature device, which is capable of performing any combination of the three following functions: (1) long-time delay tripping, (2) short-time delay tripping, and (3) instantaneous tripping.

Short-time tests of 30-cycle duration were made with the current equal to the interrupting rating with no welding, no change in physical appearance, and no change in electrical performance of the contacts. Also, two forms of duty cycles were performed at full rating on this line of breakers. These were (1) open—2 minutes—close and instantaneously tripped, and (2) open—2 minutes—close and delay tripped. The latter test demonstrates close-and-latch ability for selective systems application. Minimum size enclosures used in tests presented a metallic grounded surface $1^{5}/_{16}$ inches above the 27-inch height of the breaker base. The total short-circuit duration of the breakers equipped with instantaneous tripping is 3 to 4 cycles, depending upon the size of the breaker.

The design of the new line of circuit breakers has combined a new means of contact operation and the stored-energy mechanism with the multislot interrupter to give short-time rating and close-and-latch rating equal to the interrupting ratings. It gives greatly increased ability on repetitive-duty applications to meet the starting duty of large low-voltage a-c motors.

Figure 1. Three electrically operated air circuit breakers rated 4,000, 3,000, and 1,600 amperes (from left to right). Breakers shown are equipped for application in drawout switchgear

Digest of paper 53-149, "New Line of Low-Voltage Air Circuit Breakers," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Not scheduled for publication in AIEE *Transactions*.

B. S. Beall, III, and V. N. Stewart are with the General Electric Company, Philadelphia, Pa.

Boiler Designs Developed for Controllability

P. R. LOUGHIN

OPERATION OF A CENTRAL-STATION steam-generating unit requires continuous automatic control of water level, steam temperature (both high-pressure and reheated steam), and drafting equipment. Modern boiler designs have features which facilitate automatic control.

A tremendous stride in water level control was made by development of the cyclone steam separator. Converting some of the energy of circulation into centrifugal separating force, this device not only separates water from steam so that high-quality low-solids-content steam is delivered to the turbine, but also separates steam from the boiler water so that steam-free water is supplied to the boiler downcomers, thereby reducing water level fluctuations when steam pressure or boiler load changes. Furthermore, it permits high-quality steam to be maintained despite wide variations in water level. The burden on water level control equipment thus is reduced, and control simplified.

Accurate control of steam temperature is important in maintaining high plant efficiency while protecting equipment from excessively high temperatures. Increased fuel costs and the need to operate even new equipment at partial loads have put increasing emphasis on the attainment of design steam temperature over a wide range in load. The revival of the reheat cycle has added another steam temperature which must be controlled, with the further complication that the distribution of heat absorption between superheater and reheater varies with load. Variations in operating conditions, such as furnace wall cleanliness, also must be accommodated. A number of different methods of providing steam temperature control have been developed, including spaced burners, spray attemperators, submerged attemperators, gas flow proportioning dampers, flue gas recirculation, and furnace wall blowers. In most installations two or more of these methods are combined to produce the required high-pressure and reheated steam temperatures over the desired range of load and operating conditions.

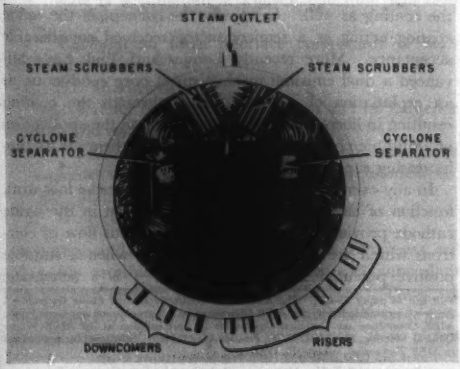

Figure 1. Cyclone steam separators

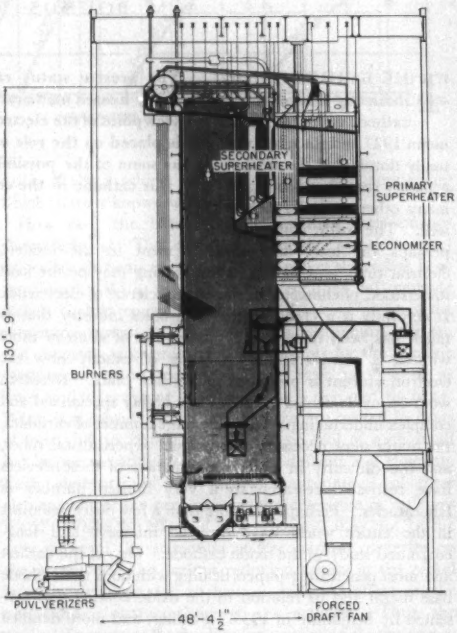

Figure 2. Gas recirculation for steam temperature control

The complexities of controlling two sets of fans (operating in series with each other), so that the correct combustion and furnace draft conditions are maintained at all times, have been simplified by the development of central-station boilers with gastight casings for operation under pressure. Furthermore, elimination of air infiltration into the boiler setting reduces the total quantity of gas to be handled, as well as reducing the draft loss through the unit. The induced-draft fan may be omitted entirely, or furnished for intermittent use under special conditions. The forced-draft fan handles only clean, cold air, and requires less power than a combination of forced- and induced-draft fans. The maintenance of the induced-draft fan, which handles hot, dust-laden gases, essentially is eliminated.

Digest of paper 53-140, "Boiler Designs Developed for Controllability," recommended by the AIEE Committees on System Engineering and Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Not scheduled for publication in AIEE *Transactions*.

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The Nickel-Base Indirectly Heated Oxide Cathode

A. M. BOUNDS P. N. HAMBLETON

The present status of the barium-oxide indirectly heated oxide cathode is reviewed from the viewpoint of the electronics engineer. Emphasis is placed on the role of the cathode alloy as well as some of the possibilities and shortcomings of this cathode in the commercial electron tube.

THE BARIUM-OXIDE indirectly heated oxide cathode came into wide use in 1927 and since has virtually dominated the field of ordinary receiving tubes and many other special types as well. The oxide cathode is perhaps the least understood element in the modern electron tube, and indeed its functioning may be the least understood phenomena in the entire science of electronics. It certainly is a credit to the electronics industry that so much has been done in the application of electron tubes without a complete understanding of exactly how the electron current is produced in the first place. Research work on oxide-coated cathodes is a highly specialized and complex undertaking. The very large number of variables, the many steps necessary to construct experimental tubes, and the difficulty in exact reproduction of these devices have restricted research to a very limited number of laboratories. Perhaps not more than a few dozen scientists in the entire world have directed intensive and long-continued study to the oxide cathode. One of the earliest and most penetrating papers dealing with both the cathode base metal and its relation to the oxide coating was presented by Benjamin[1] in 1935. Further, and more detailed information has been developed by Sproull,[2] Eisenstein[3] and his associates in this country, and by Herrmann and Wagener[4] in Germany, Loosjes and Vink[5,6] in Holland, Violet[7] in France, and D. A. Wright[8] in England.

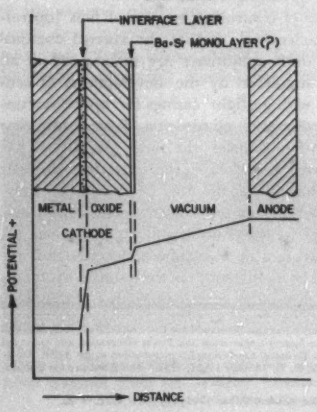

Figure 1. Schematic view through a diode tube with potential distribution approximation

The oxide cathode has been spoken of as an element in the electron tube, and so it usually is considered by tube engineers. It really is a complex system composed of a metal cylinder or sleeve and a coating of alkaline earth-metal carbonates initially held in place by a nitrocellulose binder. These carbonates of barium, strontium, and sometimes other additives must be carefully controlled as to shape, size, purity, and composition ratio. By a combination of evacuation and heating the carbonates are converted during tube processing to an adherent coating of oxide crystals, while the decomposed nitrocellulose binder and the carbon-dioxide gases are withdrawn as they are generated. A carefully controlled schedule of high-temperature heating, lower-temperature aging, and actual cathode current drain is required to complete activation. This process is designed to produce an optimum and stabilized electron emission from the cathode.

The precise nature of all the chemical and physical changes which occur on the coating, within the coating, and between the coating and the metal sleeve long has been the subject of speculation. An early theory held that activation was a result of electrolytic action within the mixed oxide coating, but it was not understood then that the so-called pure nickel base metal contained reducing agents which also entered into the reaction. Later, it was believed that a monolayer of free barium and strontium was formed on the outer surface of the oxide coating, and that barium impurity centers were distributed within the coating as well. Gradually the concept of the oxide coating acting as a semiconductor received considerable acceptance. More recently Loosjes and Vink have advanced a dual emission mechanism of pore conduction as an explanation of current passage through the coating resulting in liberation of free electrons upon the application of a suitable positive external field. This theory is finding increasing support at the moment.

In any event, it is generally conceded that the low work function of elemental barium and strontium in the oxide cathode provides for the release of a copious flow of electrons which are delivered to the anode when a suitable positive potential is applied. Figure 1 is a schematic

Full text of paper 53-174, "The Nickel Base Indirectly Heated Oxide Cathode—A Review," recommended by the AIEE Committee on Electronics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

A. M. Bounds and **P. N. Hambleton** are with the Superior Tube Company, Norristown, Pa.

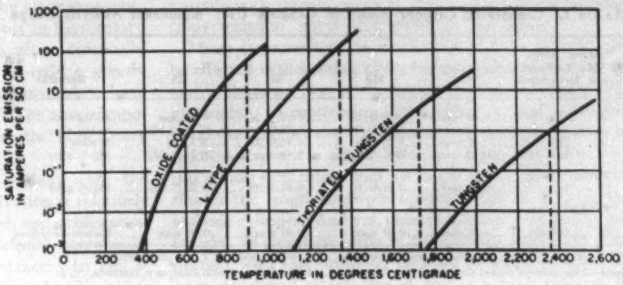

Figure 2. Saturation emission as a function of true temperature for L-cathode and three other types. Vertical dotted line indicates maximum operating temperature for each cathode. This situation can be realized under both pulse and d-c conditions for all cathodes except the oxide-coated, whose d-c emission is limited

view through a diode showing an approximation of the potential drop when the cathode is emitting electrons to the anode.

For many reasons the oxide cathode is most widely used. It is a cheap and versatile mechanism, able to provide several hundred milliamperes of direct current for short periods, lower currents for as much as 100,000 hours, and high pulse currents (tens of amperes) depending on tube design, care and control of manufacturing processes, coating materials, and techniques and choice of metallic sleeve alloy. A comparison of typical emission-current curves for oxide cathodes, tungsten, thoriated tungsten, and the *L* cathode are shown in Figure 2 which is taken from "New Cathode Design Improves Tube Reliability" by D. R. Hill of Phillips Laboratories.[9]

Just as the oxide cathode is not a single element, but rather a whole system, so the characteristics of an indirectly heated oxide cathode may be separated into distinct categories, particularly with reference to the base metal alloy on which the cathode is built. These performance characteristics are admittedly interdependent to a degree, but are sufficiently distinct to have real meaning. Cathode performance characteristics well worth careful attention are

1. Rate of activation.
2. Emission levels, direct current and pulsed.
3. Rate of sublimation at a given operating temperature.
4. Tendency to form interface compounds of high electrical impedance.
5. Life characteristics:
   A. Rate of free barium production and its influence upon grid emission.
   B. Maintenance of primary emission as it contributes to maintenance of plate current and mutual conductance.
   C. Maintenance of pulsed emission.
6. Heater-cathode leakage currents.

Coating and processing materials and techniques are extremely variable since each engineer in each tube plant has his own favorite materials and schedules. These are also dependent upon the equipment and tube types produced in the particular plant. Consequently, these phases which are still a mixture of art and science will be touched upon lightly. The discussion will center on the nickel cathode alloys which are most familiar and concerning which more is known with certainty.

How does the base metal affect these performance characteristics? The chemical reduction of earth metal oxides by elements contained in the nickel sleeve has been mentioned. With one or two exceptions all cathode nickels contain controlled amounts of one or more of the elements magnesium, silicon, titanium, aluminum, carbon, and tungsten as chemical reducing agents for the alkaline earth-metal oxide coating. These may vary from as little as 0.01 per cent to as much as 4 per cent or more. When it is considered that these alloys are melted in heats of from 700 to 20,000 pounds, the control of such small but important additives is evidently difficult and exacting. Each element and the various combinations of these elements affect the performance characteristics in different ways. While the effect of these elements may not be the only cause of the reduction of free barium, nevertheless the presence of the various reducing agents in the nickel is easily demonstrated to have a profound effect on the performance characteristics of the cathode. Thus, the choice of proper cathode alloy for particular characteristics is more important than commonly understood.

THE REDUCING ELEMENTS

In such a short summary it is not possible to review all of the major and minor effects of each of the chemical elements present in cathode nickel alloys, so only the most important and significant ones will be considered. Perhaps it should be explained first that there are a number of neutral and a few definitely poisoning elements either unavoidably present, or present for metallurgical reasons, which must be kept to reasonably low limits. The important ones are manganese, iron, copper, lead, boron, sulphur, and phosphorus. These will not be considered here.

1. *Magnesium* is the most common and important, as well as the most active, of the reducing agents. It is present in minute amounts in most of the cathode alloys and has the property of promoting rapid activation and of continuously generating free barium and strontium as they are evaporated from the surface of the oxide coating or are chemically combined to become again inactive. On the other hand, magnesium possesses a high vapor

Table I. Commercial Cathode Alloys in Common Use: Significant Analysis Range

ASTM Grade	Producer Designation	C*	Mg	Si	Ti	Remarks
"Active" Alloys						
2	DH-799	0.08 max	0.01/0.10	0.12/0.20	0.02 max	Si-Mg alloy
3	Inco 225	0.08 max	N.S. (0.03)	0.15/0.25	N.S. (0.02)	Si-Mg alloy
4	DH-599	0.08 max	0.01 max	0.15/0.25	N.S. (0)	Si alloy
	Inco 330	0.08 max	N.S. (0.10)	0.10 max	N.S. (0.02)	Mg-Si alloy
"Normal" Alloy						
11	Inco 220	0.08 max	0.01/0.10	0.01/0.05	N.S. (0.02)	Mg-Si alloy
"Passive" Alloy (1)						
21	DH-499	0.05 max	0.01 max	0.01 max	0.01 max	Carbon deoxidized

(1) Patented; * Maximum carbon in finished cathodes; N.S. = not specified; ( ) = usual content.
Inco—International Nickel Company, New York, N. Y. D-H—Driver-Harris Company, Harrison, N. J.

Table II. Commercial Cathode Alloys: Significant Analysis Ranges

ASTM Grade	Producer Designation	C*	Mg	Si	Ti	Remarks
"Active" Alloys						
1	Inco 224	0.08 max	0.01/0.10	0.12/0.20	0.02 max	Si-Mg alloy
2	DH-799	0.08 max	0.01/0.10	0.12/0.20	0.02 max	Si-Mg alloy
3	Inco 225	0.08 max	N.S. (0.03)	0.15/0.25	N.S. (0.02)	Si-Mg alloy
4	DH-599	0.08 max	0.01 max	0.15/0.25	N.S. (0)	Si alloy
5	DH-699	0.08 max	0.05/0.15	0.05/0.15	N.S. (0)	Mg-Si alloy
6	DH-399	0.08 max	0.01 max	0.15/0.25	N.S. (0)	Si alloy
	Inco 330	0.08 max	N.S. (0.10)	0.10 max	N.S. (0.02)	Mg-Si alloy
"Normal" Alloy						
11	Inco 220	0.08 max	0.01/0.10	0.01/0.05	N.S. (0.02)	Mg-Si alloy
"Passive" Alloys (1)						
21	DH-499	0.05 max	0.01 max	0.01 max	0.01 max	Carbon deoxidized
22	DH-999	0.05 max	0.01 max	0.01 max	0.01 max	Special deoxidized

(1) Patented; * Maximum carbon in finished cathodes; N.S. = not specified; ( ) = usual content.
Inco—International Nickel Company, New York, N. Y. D-H—Driver-Harris Company, Harrison, N. J.

pressure and thus promotes a high sublimation rate of the metallic sleeve often resulting in electrical leakage and shifting characteristics when the magnesium in the cathode alloy exceeds about 0.07 per cent. Magnesium does not produce a high impedance interface between cathode sleeve and coating, and therefore is satisfactory as an activator for pulsed cathodes.

2. *Silicon* is next in commercial importance. Activation is not quite so rapid as with magnesium, but d-c emission life is long and the use of silicon has become popular therefore for a number of types of cathode alloys. Silicon may be present in quantities from 0.01 to 0.25 per cent. Unfortunately silicon seems to promote the formation of an interfacial layer between cathode alloy and coating which has been identified as barium orthosilicate and which is characterized by high electrical impedance which, in turn, results in poor performance of tubes used for pulsed or cut-off purposes. Silicon displays a lower vapor pressure than magnesium and thus does not cause deposits on insulators which result in electrical leakage.

3. *Titanium* is used very sparingly and primarily for its metallurgical effects rather than for its reducing action on the coating, but there are some who have advocated a more careful examination of the usefulness of this element. It is present as a scavenger in many of the cathode alloys, but rarely in the free or uncombined state so that its effect is probably minor in quantities now used. High titanium cathode alloys have been produced in the past, resulting in the formation of a black interfacial layer which effectively reduced the operating temperature of the cathode. There seems to be disagreement as to the electrical characteristics of this interface, and it is doubtful that titanium-nickels have been used since the advent of pulse problems. Such alloys deserve more attention and they probably will be reviewed again in the near future.

4. *Carbon* apparently may act as a reducing agent on the coatings, particularly in the absence of any other highly reducing elements, but its role in cathode activation and life has been difficult to establish. Due to its high diffusion rate and the formation of gaseous compounds, any effect by carbon is probably very short-lived, but may be of importance in activation of the cathode.

The foregoing elements have been traditional reducing agents for both activation and constant regeneration of barium and strontium during life. The commercial and generally used cathode alloys, classified both on the basis of their activity and according to the particular reducing agent or agents which largely determine their performance characteristics, are shown in Tables I and II. Table I shows those in common use, while Table II shows the entire list including many which are rarely used today.

The first action of Section *A* on Cathode Alloys of American Society for Testing Materials Committee *B4*, Sub *VIII*, organized in 1945, was to divide the alloys according to activity into those which were passive, normal, and active. This terminology is not exactly definitive when related to performance characteristics, but does classify the alloys in a general way with respect to rapidity of activation and level of d-c emission during life. The rate of activation is of commercial importance to tube manufacturers, but of little importance to the tube user.

The passive metals show extremely slow activation, relatively low levels of emission, and extremely long life. The normal alloy shows relatively rapid activation, higher levels of emission, and sometimes shorter life. The active alloys are rapid in activation, give slightly higher d-c emission and related tube characteristics, and when used under proper conditions give fairly long life. These general characteristics are shown in Figure 3. However, it is our belief that all but the passive alloys are probably outmoded by today's requirements which entail better control of sublimation characteristics, complete freedom from interface impedance, longer life, and better strength.

Newer alloys which have been introduced recently are ones containing aluminum as the activating agent in one series, tungsten as both a reducing element and a strengthening element in another series, and cobalt in still another.

Now the use of these three elements is by no means new, since they are long familiar as ingredients in filamentary alloys. However, it was necessary to alter drastically the filamentary alloys, and in general to reduce greatly the content of these elements, before the alloys would behave properly for indirectly heated cathodes. The new compositions are, therefore, quite distinct from the filamentary alloys.

The advantages of aluminum are evident from the characteristics of the element itself—activation is relatively rapid, d-c emission is high and long-lived, and sublimation has proved to be very low. The interfacial compounds (if present) are of low electrical impedance. In fact it may be said here that in our experience only silicon has shown any effect in the creation of an interfacial layer of high impedance. Of course most of the reducing agents cause the formation of a visible interface layer, but these films do not necessarily show electrical impedance. There are indications that the absence of all reducing elements is necessary to the best pulsed performance, that is, passive cathode base metal is indicated.

In addition to doubling the hot strength of a cathode sleeve, the addition of approximately 4-per-cent tungsten seems to enhance the reducing potential of the cathode alloy. Tungsten-nickel alloys have shown reasonably rapid activation, long life under d-c emission conditions, relatively high emission, and complete freedom from interface impedance where the silicon content was sufficiently low. However, tungsten is a strategic element, scarce and high in price, so that tungsten-nickel alloys must be considered as premium ones for special purposes only.

Problems of reliability and shock and vibration resistance are specters which haunt tube engineers these days. Reliability is a problem not only of mechanical perfection of assembly, but also one of long life with freedom from shifts in tube characteristics. It is hoped that the aluminum alloy for indirectly heated cathodes will be a definite contribution to cathode life and stability of characteristics. On the other hand, ruggedization requires stronger cathode alloys which are, at the same time, suitable with respect to all of the afore-described cathode characteristics: not a small order by any means.

Much improvement in shock resistance of cathodes can be effected with existing alloys by the application of simple and well-known laws governing the strength of shapes and materials. In considering this problem it must be understood that the heavier the cathode, the less its resistance to deformation under shock loading. From the same laws it is almost elementary that the larger the diameter and the shorter the length between supports, the stronger is the cathode cylinder. And yet, these simple facts apparently are ignored or forgotten often in tube design work. In connection with this problem, cathode strength curves have been developed which should enable a tube designer to predict with considerable accuracy the resistance of an indirectly heated cathode to shock loading. Figure 4 shows these curves for cathodes operating at a temperature of 775 degrees centigrade. The Bureau of Ships, Department of the Navy, has permitted publication of this small portion of our recent contract development work in the hope that it will be an aid in the design of more rugged and reliable tubes.

In conclusion, it is desirable to emphasize a number of points which derive from the foregoing discussion. The complex oxide cathode structure is temperature dependent, not only as to electron emission but also as to chemical, metallurgical, and physical reactions. It is not an inexhaustible well of electrons; it must not be driven beyond its electron-producing capacity simply by raising the temperature or raising the anode voltage or using a positive grid bias. It cannot be expected to stand up if bombarded by positive ions which act like cannon balls in destroying the emissivity of the coating. Many of the apparent weaknesses of the oxide cathode stem from its misuse and a lack of understanding and appreciation of its characteristics.

Circuit engineers must know a great deal about the internal workings and theories of electron tubes and electron emission, as well as all about the circuits in which they are applying these tubes. When special applications of tubes are involved, it is always necessary for the circuit

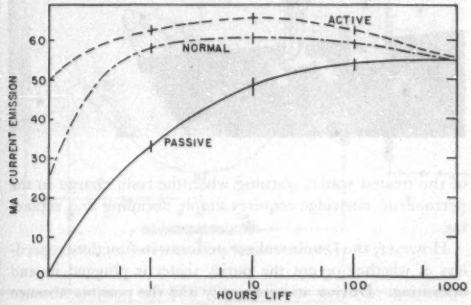

Figure 3. Rate of activation and emission levels typical of active, normal, and passive cathode base materials as tested in the standard American Society for Testing Materials' diode

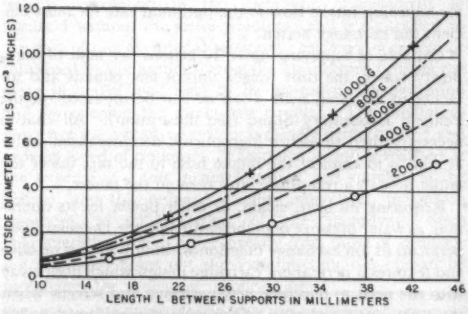

Figure 4. Relation of outside diameter and length between supports for round nickel tubing 0.002-inch wall thickness at several acceleration values and 775 degrees centigrade (based on 0.001-inch deflection at mid-point between supports)

engineer to consult with the applications engineers of the tube manufacturers or with specialists in this field within his own organization. Relatively small differences in applied voltages and signals may be vital; they may change the tube life from 10,000 hours to a matter of hundreds of hours in a most unexpected fashion. To achieve reliability, tubes should be underrated as much as is economically possible. Tubes must be processed for the application for which they are intended.

It also must be recognized that the complexity of materials and processes which are incorporated in the vacuum tube make it difficult both to substitute new alloys in old designs and really to evaluate the effects of these new materials. It also is well known that slight changes in tube characteristics, from whatever cause, greatly complicate the production of replacement tubes. Nevertheless, particularly in the design of new tubes, the electron tube industry now has an opportunity to achieve the reliability and ruggedness required by new and severe applications and specifications through an improved understanding of the indirectly heated oxide cathode and the predictable effects of the nickel alloy used as the base metal.

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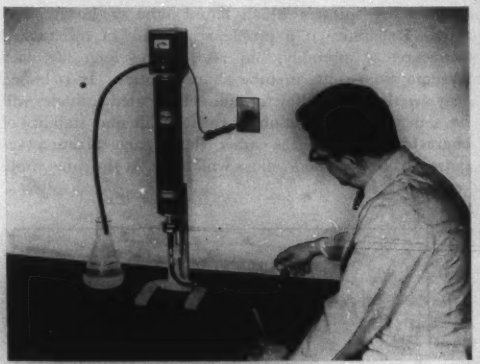
Permanent Cartridge Demineralizer Provides High-Purity Water

Employing the monocolumn demineralizing method (a mixed bed of cation and anion resins in a single column) which is effective in the decontamination of water containing mixed fission products, the Penfield Permanent Cartridge Demineralizer is designed to provide mineral-free water for commercial users of reasonable quantities of high-purity water and is also useful as a stand-by or shelf unit for emergency use in hospitals, schools, and defense centers.

The Demineralizer features a permanent cartridge, an electric purity indicator, and a flow meter, a sight indicator for adjusting intake flow to the optimum rate for most efficient ion exchange action.

Capable of supplying up to 10 gallons per hour of high-purity water, the unit weighs only a few pounds and attaches to any wall near a tap or can be mounted on the Penfield Laboratory Stand (see illustration). All that is necessary then to secure high-purity, demineralized water at will, is to connect the intake hose to the tap, insert the outlet hose in a receptacle, and turn on the faucet.

Requiring no heat, steam, or other power for its operation, as water pressure does the entire job, the Demineralizer performs its ion exchange function without boil-outs or odor and features a permanent cartridge design which does away with the need to purchase new cartridge and screens when the resins need replacing. One resin charge furnishes 200 to 230 gallons of mineral-free water. The electric purity meter built into the unit plugs into any a-c outlet to provide continuous conductivity information relative to the purity



of the treated water, warning when the resin charge in the permanent cartridge requires simple dumping and replacing.

However, the Demineralizer performs its functions regardless of whether or not the purity meter is plugged in and operating. During an emergency and the possible absence of electric power, all that is necessary is to turn the faucet to optimum intake flow rate, as indicated on the flow meter, and keep track of gallonage output so that the resin charge may be replaced at proper intervals.

Transient Analysis of the Metadyne Generator

M. RIAZ
ASSOCIATE MEMBER AIEE

Vol. 72
1953

SINCE WORLD WAR II, the increased use of direct current for ship propulsion, aircraft systems, and feedback control systems has refocused attention on the potentialities offered by d-c machines in many novel forms. However, the full possibilities of these machines can be realized only after consideration of a more general class of machines known as metadynes. This article presents an analysis of the transient performance of one fundamental type: the so-called S-generator or cross-connected metadyne.

The metadyne constitutes a generalization of the conventional d-c machine in which special use is made of armature reaction to control the machine characteristics. This utilization of armature reaction is obtained through placing extra sets of brushes between those of the conventional d-c machine. An elementary S-generator metadyne is shown schematically in Figure 1 with several kinds of series windings placed on the stator to control its steady-state and transient characteristics.

The transient equations describing the performance of this metadyne are obtained by adapting some fundamental elements of matrix analysis (as developed by Kron) to the case of commutator machines of the metadyne type. The method, so to speak, suggests itself logically not only because of its complete automaticity and great power but also because it particularly fits the case of a generalized concept such as the metadyne, which can be viewed as a physical representation of Kron's "primitive" machine. Commutation, the effects of saturation, and the non-sinusoidal distribution of flux densities are included as characteristic of the structure of a commutator machine.

The solutions of the equations reveal unique characteristics: notably, the constant-current behavior inherent to the metadyne, which is demonstrated under transient conditions by a strong field-forcing action causing the quick response of the machine. A typical transient response is illustrated in the oscillograms of Figure 2 (which correspond to the metadyne arrangement of Figure 1 without the series windings) and is contrasted to the case of a conventional separately excited d-c generator (obtained by connecting across the quadrature brushes the same inductive load used in the metadyne configuration and by opening the direct-axis circuit). The oscillatory nature of the metadyne system is clearly demonstrated and so is its speed of response. This quick action is realized at the expense of a loss in amplification and stability of the system, and this reduced stability may lead, in certain instances, to self-excitation of the metadyne. Such characteristics, which differ greatly from those of ordinary d-c machines, point out the vast potentialities offered by metadynes for industrial applications.

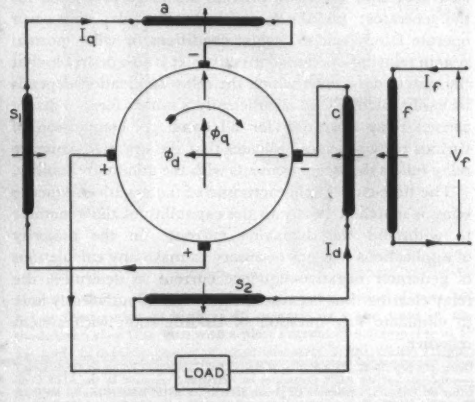


Figure 1. Metadyne generator

f = control field winding
c = compensating winding
s = stabilizing winding
a = amplifying winding

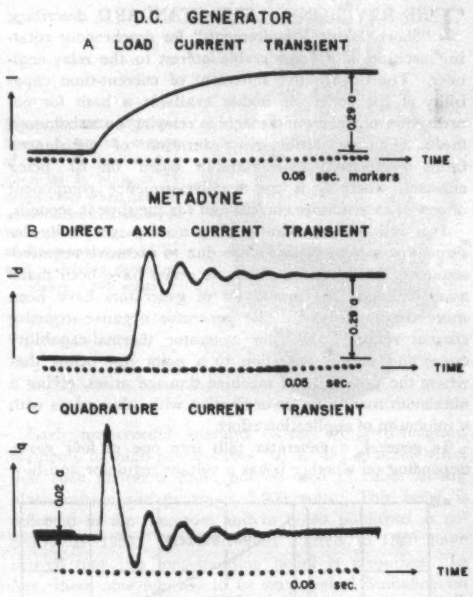


Figure 2. Transient response

Digest of paper 53-84, "Transient Analysis of the Metadyne Generator," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Using Relays for Unbalanced Faults on Generators

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MEMBER AIEE

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THE REVISION OF THE STANDARD describing "Short-Circuit Requirements" for synchronous rotating machines is of considerable interest to the relay engineer. The quantitative statement of current-time capability of the generator makes available a basis for co-ordination of system and machine relaying on unbalanced faults. The permissible time duration of unbalanced faults is expressed as a variable based on I_2^2t being constant, where I_2 is the negative-sequence component of generator armature current and t is the time in seconds.

It is desirable to consider using a relay specifically designed to prevent rotor failure due to excessive negative-sequence current, since adequate relays have been made available and the capabilities of generators have been more closely defined. The generator negative-sequence current relays match the generator thermal-capability curve and permit operation to a point just below that where the possibility of machine damage arises, giving a maximum margin for co-ordination with other relays with a minimum of application effort.

In general, a generator falls into one of four cases, depending on whether it has a voltage regulator and how it is connected to the system: A. Generator without a voltage regulator connected directly to the system; B. Generator without a voltage regulator connected to the system through a transformer; C. Generator with a voltage regulator connected directly to the system; D. Generator with a voltage regulator connected to the system through a transformer.

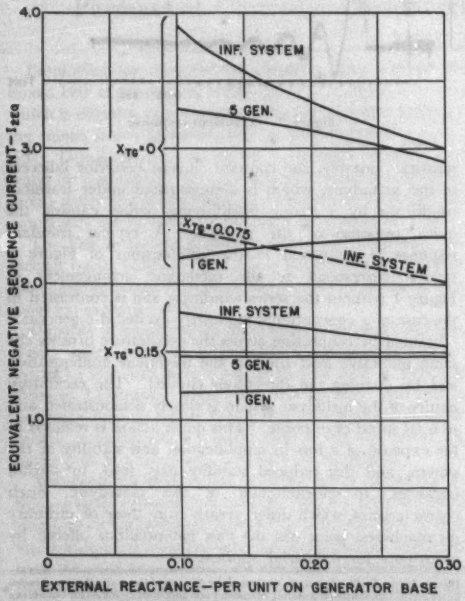

Figure 1. Equivalent negative-sequence current in generator for line-to-line faults as a function of external reactance, generator transformer reactance, and system size

In applying a generator negative-sequence current relay, the relay engineer is concerned about the closing time of the relay for different faults, in order to check the co-ordination with system relaying. The minimum closing time is caused by a line-to-line fault, which gives the largest magnitude of negative-sequence current for a given fault location.

Figure 1 shows the results of studies of various systems under cases A and B. The equivalent negative-sequence current is that constant value of current such that I_{2eq}^2t is equal to the integrated product of i_2^2t, where i_2 is variable as a function of time. For a turbine generator the standard limits I_2^2t to 30, and an equivalent negative-sequence current of 2.74 per unit gives a permissible time of 4 seconds. Figure 1 shows that a generator connected to a system of any size through a transformer (case B) gives a current less than 2.74 per unit, with ample time for relay co-ordination. Generators using voltage regulators give higher values of negative-sequence current because of the forcing effect of the regulator. The sustained current is increased for prolonged faults, and for practical purposes the equivalent negative-sequence current can be set equal to the sustained magnitude.

Two aspects of generator negative-sequence current relaying warrant almost equal weight: the first is the assurance that the relay provide adequate protection for the generator; and the second is that the relay must never operate falsely under normal conditions or when normal system relaying operates correctly. It is also desirable that the system data upon which the relay application depends be easily calculable in a sufficiently accurate form to assure correct relay operation for all cases. A comparison of various relay schemes indicates that the negative-sequence relay fulfills these requirements with the greatest reliability.

The time-current characteristic of the negative-sequence relay is matched closely to the capability of the generator to withstand the damaging current. In the majority of applications it is not necessary to make any calculations of generator negative-sequence current to determine the relay clearing time because the time will be sufficiently long to eliminate any question of co-ordination with system relaying.

Digest of paper 53-41, "Application of Relays for Unbalanced Faults on Generators," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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High-Power Industrial Vacuum Tubes

R. B. AYER

THORIATED-TUNGSTEN WIRE, developed nearly 40 years ago by the lamp industry, has found extensive application as an electron emitter in vacuum tubes over the last 30 years, first in receiving and small-power types and more recently in high-power industrial types such as the *RCA-5770*, *RCA-5771*, and *RCA-5831*. High-power types are considered as those having unmodulated class *C* plate voltage ratings of greater than 5,000 volts.

Emission efficiencies 10 to 15 times that of pure tungsten are obtained at operating temperatures 500 to 600 degrees Kelvin lower than that of pure tungsten. Processing of thoriated-tungsten filaments involves high-temperature flashing, first in an appropriate gas atmosphere to carburize the wire and then in a vacuum to produce metallic thorium and diffuse it to the surface. In carburization, a thin shell of tungsten carbide is formed to aid in maintaining filament activation and in achieving longer life. Data on the rate of loss of this carbide as a function of operating temperature have made it possible to predict the emission life of thoriated-tungsten filaments.

Figure 2. RCA-5771 delivers a power output of over 50 kw at frequencies as high as 25 megacycles when used in unmodulated class C service with a plate current of 4.5 amperes at 15 kv and a driving power of about 1,160 watts

Early unsuccessful attempts to use thoriated-tungsten filaments in high-power tubes led to the general belief that such filaments could not be used in tubes having plate voltage ratings above 5,000 volts. This belief is reflected in the literature and in books published as recently as 1951. However, tests started in 1940 have proved that this long-standing belief is erroneous. In fact, there now appears to be no practical limitation on the power or operating plate-voltage level. New materials, simplified mechanical structures, improved processing facilities, and greater cleanliness have contributed to the successful use of thoriated-tungsten filaments in high-power industrial tubes.

Examples of such tubes are the *RCA-5770*, *RCA-5771*, and *RCA-5831*. These tubes have output capabilities ranging from 50 to 500 kw, plate voltage ratings between 15 and 17 kv, and maximum frequency ratings at full input from 1,600 kc up to 25 megacycles. Operation in induction-heating and in dielectric-heating applications has been exceptional with no evidence of deterioration even after approximately 3 years of continuous service.

A saving of 60 to 70 per cent in filament heating power over that required for equivalent pure-tungsten filament types results in a substantial saving in operating costs. As an example, the *RCA-5770* requires 5.0 kw less filament power than its pure-tungsten equivalent. Other advantages resulting from the lower operating temperature make these tubes very attractive for industrial use where long life and reliable performance are of paramount importance.

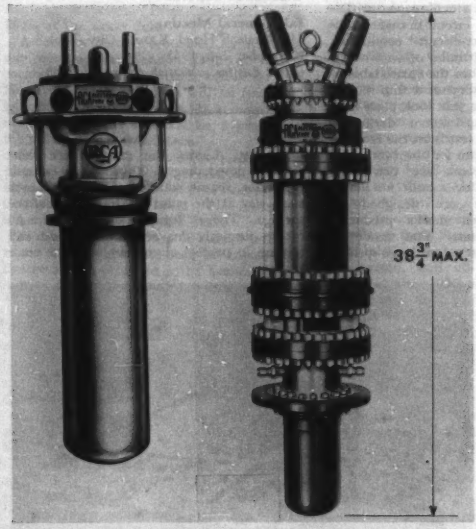

Figure 1 (left). RCA-5770 delivers a power output of over 100 kw at frequencies as high as 20 megacycles when used in unmodulated class C service with a plate current of 8.5 amperes at 17 kv and a driving power of approximately 2,300 watts. (Right) RCA-5831 water-cooled superpower beam triode delivers a power output of approximately 500 kw at frequencies up through the standard broadcast band when used in unmodulated class C service with a plate current of 39 amperes at 16 kv and a driving power of approximately 900 watts

Digest of paper 53-173, "High-Power Industrial Vacuum Tubes Having Thoriated-Tungsten Filaments," recommended by the AIEE Committee on Electronics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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INSTITUTE ACTIVITIES

Summer Meeting in Atlantic City to Feature Week of Technical and Social Activities

A full week of technical sessions and social activities awaits those who plan to attend this year's Summer General Meeting, June 15–19. With one of the country's foremost seaside resorts, Atlantic City, N. J., as the site, members of the AIEE Philadelphia Section will act as hosts for this meeting which also commemorates the Section's 50th anniversary. Headquarters will be at the Chalfonte-Haddon Hall Hotels on the boardwalk.

The week's program will open with the annual meeting on Monday, at which the election of officers will be announced and President D. A. Quarles will deliver the main address. A feature of the session will be the presentation of the Lamme Medal to I. F. Kinnard "for his outstanding contributions in design and developments in the field of instrumentation and measurements."

Professor Edwin H. Armstrong, Columbia University, was elected an Honorary Member by the Board of Directors, and he will address the General Meeting.

INSPECTION TRIPS

Station WFPG-TV, Atlantic City, N. J. (Tuesday and Wednesday, June 16 and 17). Trips will be made through this new ultra-high-frequency–television station on the afternoons of both days.

Bell Telephone Company of Pennsylvania, Philadelphia, Pa. (Thursday and Friday, June 18 and 19). The Automatic Message Accounting center recently established in Philadelphia has been designed to mechanize the operations which summarize and compute data on telephone calls for the purpose of billing the customer. As calls are dialed by the customers all of the items of information relating to a call are recorded on paper tape by means of perforations. At the accounting center, these data are collected automatically and the charges for the calls computed. This is one phase of the development which soon will enable the customer's bill to be printed automatically.

Westinghouse Electric Corporation, Lester, Pa. (Thursday and Friday, June 18 and 19). Members making this trip will see, in the process of manufacture, assembly, and test, such apparatus as industrial and central station turbines for driving generators, mechanical-drive turbines, surface condensers, heat exchangers, circulating and condensate pumps, and evaporators.

Proof of citizenship will be required by those planning to make this trip.

General Electric Company Switchgear Development Laboratory, Philadelphia, Pa. (Thursday and Friday, June 18 and 19). This is the largest and most modern laboratory of its type in the world. In its control building are centralized control and instrumentation equipments which indicate or record every electrical phenomenon which proves or disproves the value of circuit-breaker performance under short-circuit conditions. From these devices 400 miles of wire reach out to every device within the entire laboratory. In a matter of seconds a film record of electrical phenomena that took place in a switchgear interrupting device during a regular or short-circuit test is on the reading tables in the control room for observation.

In the generator room are two huge generators, the largest ever built for short-circuit testing. They are designed to absorb the tremendous shocks produced during short-circuit tests. The stator of each generator is supported on huge spring-steel legs. Under the most severe short circuit, developing 8,000,000 foot-pounds of torque, frame rotation is about 1/2 inch each way at the point of attachment of the springs. These "legs" allow the stator to rotate through this small angle and still remain in perfect alignment with the rotor

Future AIEE Meetings

Summer General Meeting
Chalfonte-Haddon Hall Hotels,
Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—closed*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 30*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Aircraft Electric Equipment Conference
Benjamin Franklin Hotel, Seattle, Wash.
September 30–October 2, 1953

Conference on Fractional-Horsepower Motors
Hotel Van Orman, Fort Wayne, Ind.
October 6–8, 1953

Conference on Machine Tools
Cleveland Hotel, Cleveland, Ohio
October 14–16, 1953

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

(Left) The famed Atlantic City boardwalk with the Chalfonte-Haddon Hall Hotels in the background and (right) an aerial view of the beach

shaft. They take the brunt of the short circuit instead of the windings under short-circuit conditions.

In the high-voltage yard are huge power transformers capable of stepping up the voltage to 400,000 volts for testing circuit breakers and other equipment. In this same area are capacitor banks for simulating actual conditions such as charging currents on high-voltage transmission lines up to 200 miles in length at 230,000 volts.

Limited accommodations are available. Reservations must be made at Atlantic City at time of registration.

In addition to these inspection trips, as a special feature of the meeting, motion pictures covering various industrial and educational subjects will be shown each afternoon, Monday through Friday, in the Viking Room of Haddon Hall.

SOCIAL ACTIVITIES

A number of social activities have been planned for the evenings during the meeting by a committee under the chairmanship of J. B. Harris.

An informal bingo and card party will be held on Monday evening, for which there will be no charge. Refreshments and prizes will be provided.

On Tuesday, cocktails will precede a dinner and show featuring Vivian Della Chiesa, popular radio soprano; Conrad Thibault, well-known baritone; the Harmonicaires, harmonica band; and the dance team, Laurette and Clymas. The accompaniment will be furnished by Howard Lanin's orchestra. Price per ticket is $8.50 at the ticket desk.

A cabaret dance is scheduled for Wednesday evening at Haddon Hall at which cocktails and other beverages will be served. Howard Lanin's orchestra will be featured, in addition to a female vocalist and a square dance group. Tickets will be available at the ticket desk at $2.50 each.

For Thursday, a moonlight boat trip is planned along the coast of Atlantic City. Bus transportation will be provided to and from the hotel to the dock. The price per ticket is $2.00 at the ticket desk.

A number of activities of special interest to the ladies also have been arranged. In charge of this program is the Ladies' Committee under the chairmanship of Mrs. H. R. Paxson.

On Sunday afternoon, an informal tea will be held for AIEE members and their families, and on Monday afternoon the ladies are invited to take a complimentary sight-seeing trip around the island and down to Ocean City.

A luncheon and millinery show are planned for Tuesday at the Marlborough-Blenheim Hotel at which hats will be modeled by the visitors and one of the hats awarded as a door prize. Luncheon tickets will be $3.00 each.

A marine sight-seeing trip has been scheduled for Wednesday morning. Both bus transportation to the dock and the boat trip are free-of-charge.

On Thursday morning an inspection tour will be made through the Haddon Hall kitchens and laundry.

SPORTS

The sports program under the leadership of A. D. Brown has been rounded out to include arrangements for the duffer and amateur as well as the seasoned golfer and angler.

Facilities for golf will be available at the Atlantic City Country Club at Northfield, N. J. The green fee is $4.00 on weekdays. Ladies and men both may participate and the facilities of the pitch and putt course and putting greens may be used also. Golf scores and scores for the pitch and putt course and putting contests should be turned in to the AIEE Sports Committee representative. There will be prizes for both ladies and men.

For those interested in fishing, half-day trips leave from Starn's Boat Dock, Atlantic City Inlet, at an approximate cost of $3.25 per person, and all-day fishing trips are available also. Deep-sea sport fishing can be arranged at a day's notice. These boats accommodate six persons and the rate is approximately $65 for weekdays. Tackle may be rented by the hour or day. There will be prizes for the largest and smallest fish; men, women, and children may compete.

Small power boats accommodating five people can be had for $12 rental for the day or at special hourly rates.

RESERVATIONS AND REGISTRATION

The Summer General Meeting, while it assuredly has its serious technical aspects, also can afford the opportunity for a pleasant vacation; hence the selection of Atlantic City as this year's meeting site. This thought was carried out also in the assignment of the Chalfonte-Haddon Hall Hotels as meeting headquarters.

A Hotel Accommodations Desk, devoted exclusively to the best utilization of the hotels' numerous facilities, will be established in the registration area.

Transportation to Atlantic City can be arranged very easily from both Philadelphia, Pa., and New York, N. Y. It can be reached by bus from Philadelphia and New York City; by train from 30th Street Station, Philadelphia, via Pennsylvania-Reading Seashore Lines; by automobile from New York City via the New Jersey Turnpike, thence on Route 43, also via Route 9; by automobile from Philadelphia via Route 43; by airplane from New York's Idlewilde Airport and Philadelphia's International Airport.

The Registration Desk will be open Sunday afternoon, June 14, from 2:30 to 4:30 and daily thereafter from 8:30 a.m. to 4:30 p.m. for the duration of the meeting. A registration fee of $3.00 will be charged all members and of $5.00 for nonmembers. Enrolled students and guests will be registered without payment of registration fees.

Directors, officers, and delegates will be registered in advance and may receive credentials from a desk provided for this purpose in the registration area.

COMMITTEE

The members of the 1953 Summer General Meeting Committee are: L. R. Gaty, General Chairman; B. L. England, W. F. Henn, Vice-Chairmen; R. W. Wilbraham, Treasurer; A. C. Muir, Institute Director; R. M. Pfalzgraff, D. B. Smith, Members-at-Large; J. C. Strasbourger, Vice-President, District 2; W. F. Denkhaus, Arrangements; J. B. Harris, Jr., Entertainment; R. W. Wilbraham, Finance; H. F. Davis, Hotels; Mrs. H. R. Paxson, Ladies; M. L. Stoughton, Publicity; T. E. Stieber, Registration; A. D. Brown, Sports; Arthur Pringle, II, Inspection Trips and Science Theater; S. R. Warren, Students; W. R. Clark, Technical Program; W. G. Salmonson, Transportation.

Lamme Medal Nominations for 1953 Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1954, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal Committee, as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that: "The committee in making the award shall carefully observe the limitation imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electric apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electric apparatus or machinery. Any work which meets this requirement is admissible whether it be (*a*) in development of the theory involved; (*b*) in development of the characteristics of the materials employed; (*c*) in development of over-all design; or (*d*) in development in other ways which results in substantial improvement in electric apparatus or machinery. The words 'electric apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

Tentative Technical Program

Summer General Meeting, Atlantic City, N. J., June 15-19

Monday June 15

10:00 a.m. Annual Meeting

1. Report of Board of Directors. H. H. Henline, Secretary
2. Report of Treasurer. W. J. Barrett
3. Report of Committee of Tellers on:
   (a). Votes for nominees for AIEE offices
   (b). Proposed Constitutional amendments
4. (a). Introduction of, and presentation of President's badge to, Elgin B. Robertson
   (b). Response by Mr. Robertson
5. Introduction of District Branch prize winners
6. Presentation of Lamme Medal to I. F. Kinnard, General Electric Company, West Lynn, Mass.
   (a). The Establishment of the Medal. Lester L. Bosch, Chairman, Lamme Medal Committee
   (b). The Career of the Medalist. Everett S. Lee, Editor, *General Electric Review*, Schenectady, N. Y.
   (c). Presentation of the medal and certificate by President D. A. Quarles
   (d). Response by Mr. Kinnard
7. Any other business that may be presented
8. Address by Professor Edwin H. Armstrong, Columbia University
9. Address by President D. A. Quarles

2:00 p.m. Protective Devices

53-272. Change in Resistance of Aircraft Current Limiters and Its Effect on Current Division in Networks. *Henry Oman*, Boeing Airplane Company. Re-presented for discussion

53-185. The Duty on Expulsion-Type Lightning Arresters for Distribution Systems. *Otto Ackermann*, Westinghouse Electric Corporation. Re-presented for discussion

53-273. Use of 10×20 Current Waves for Lightning Arrester Tests. *H. A. Cornelius*, Public Service Company of Northern Illinois. Re-presented for discussion

53-274. Ground Fault Neutralizer Grounding of Unit-Connected Generators. *H. R. Tomlinson*, New England Power Service Company

53-201. Application Guide on Methods of Neutral Grounding of Transmission Systems. *Working Group of the AIEE Subcommittee on Fault Limiting Devices*. Re-presented for discussion

2:00 p.m. Electronic Power Converters

53-288. Water Cooling Systems of Mercury-Arc Rectifiers. *Working Group on Water Cooling Systems of Mercury-Arc Rectifiers*

CP. Low-Temperature Operation of Ignitrons.** *H. E. Zwiers, J. L. Zehner*, General Electric Company

CP. Mechanical Rectifier Circuits and Transformer Connections.** *E. J. Diebold*, I-T-E Circuit Breaker Company

53-242. Voltage Regulation of 12-Phase Double-Way Rectifiers. *R. L. Witzke, J. V. Kresser, J. K. Dillard*, Westinghouse Electric Corporation

53-271. Equivalent Machine Constants for Rectifiers. *I. K. Dortort*, I-T-E Circuit Breaker Company. Re-presented for discussion

2:00 p.m. Substations

53-104. Performance of Electrical Joints Utilizing New Silver Coating on Aluminum Conductors. *T. J. Connor, W. R. Wilson*, General Electric Company. Re-presented for discussion

53-237. Substation 1-Line Diagrams. *Working Group on 1-Line Diagrams of the Committee on Substations*

53-238. Reclosing Fuses, Automatic Oil Circuit Reclosers, and Automatic Reclosing Circuit Breakers in the Distribution Substation. *Working Group on Breakers Versus Reclosing Fuses of the Committee on Substations*

53-239. Grounding Grids for High-Voltage Stations. *E. T. B. Gross*, Illinois Institute of Technology; *B. V. Chitnis*, American Gas and Electric Service Corporation; *L. J. Stratton*, Armour Research Foundation

53-240. Design Charts for Determining Optimum Ground Rod Dimensions. *J. Zaborszky, J. W. Rittenhouse*, University of Missouri

53-241. Lightning Protection in Extra-High-Voltage Stations—Influence of Multiple Circuits. *I. W. Gross*, American Gas and Electric Corporation; *L. B. LeVeconte*, Sargent and Lundy; *J. K. Dillard*, Westinghouse Electric Corporation

2:00 p.m. Facsimile

53-297. A Level Compensator for Telephotograph Systems. *T. A. Jones, W. A. Phelps*, Bell Telephone Laboratories, Inc.

CP. Transmitting X-Ray Photographs by Facsimile.** *K. R. McConnell*, Times Facsimile Corporation

CP. The Facsimile Transmission of News and News Photographs for Television.** *J. V. L. Hogan*, Hogan Laboratories, Inc.; *Dewey Frezzolini*, International News Photos

CP. A Discussion of Synchronizing Systems.** *F. T. Turner*, Western Union Telegraph Company

2:00 p.m. Storage Batteries

Tuesday, June 16

9:00 a.m. Section Delegates Conference

9:00 a.m. Electrical Techniques in Medicine and Biology

CP. Miniature Electrostatic Sources of High Voltage for Radiation Instrumentation.** *S. R. Gilford, S. Saito*, National Bureau of Standards

CP. An Electronic Flowmeter.** *H. P. Kalmus*, National Bureau of Standards

CP. Measurements of Materials With High Dielectric Constant and Conductivity at Ultrahigh Frequencies.** *H. P. Schwan, Kun Li*, University of Pennsylvania

53-206. Heating of Fat-Muscle Layers by Electromagnetic and Ultrasonic Diathermy. *H. P. Schwan, E. L. Carstensen, Kun Li*, University of Pennsylvania

9:00 a.m. Television

CP. An Ultrahigh-Frequency Transmitter Employing a Klystron Power Amplifier.** *W. H. Sayer, Jr.*, Allen B. Du Mont Laboratories

53-299. Technical Characteristics of FTL Type Number 20-B Ultrahigh-Frequency Television Transmitter. *E. M. Bradburd*, Federal Telecommunication Laboratories

CP. Review of Television Abroad.** *E. A. Laport, C. W. Slaybaugh*, RCA International

CP. Engineering Plans for Theater Television.** *A. Forman*, Tele-Tech

CP. The Chromatron, A Single or Multigun Tricolor Cathode-Ray Tube.** *R. Dressler*, Chromatic Television

9:00 a.m. Relays

53-195. An Analysis of Polyphase Directional Relay Torques. *C. J. Baldwin, Jr.*, Westinghouse Electric Corporation; *B. N. Gafford*, University of Texas

53-200. A Pilot-Wire Relaying Scheme Utilizing the Product Differential Relay. *R. I. Ward, D. W. Gilman*, Commonwealth Edison Company

53-210. Field Experience—Electronic Mho Distance Relay. *H. C. Barnes*, American Gas and Electric Service Corporation; *R. H. Macpherson*, General Electric Company

53-211. Phase Comparison Carrier Relaying for 3-Terminal Lines. *H. W. Lensner*, Westinghouse Electric Corporation

9:00 a.m. New Developments in Digital Computers

53-286. Pulse-Response Characteristics of Rectangular-Hysteresis-Loop Ferromagnetic Materials. *Joseph Wylen*, Burroughs Adding Machine Company

CP. A High-Speed Special-Purpose Computer Using a Magnetic Drum Memory.** *R. T. Gordon*, General Electric Company

CP. Phase System of Magnetic Recording as Used for the EDVAC Drum Memory.** *Donald Eadie*, University of Florida

53-287. A Progressive Code Digital Quantizer. *Floyd Raasch*, Minneapolis-Honeywell Regulator Company

9:00 a.m. Instruments and Measurements

53-281. 40- to 4,000-Microwatt Power Meter. *R. W. Lange*, Bell Telephone Laboratories, Inc.

53-197. The Use of Steel Sheet for the Construction of Shielded Rooms. *A. M. Istrator*, United States Naval Civil Engineering Research and Evaluation Laboratory

CP. Precise Measurement of Repeater Transmission.** *T. Slonczewski*, Bell Telephone Laboratories, Inc.

CP. The Quasi-Peak Voltmeter.** *C. W. Frick*, General Electric Company

9:00 a.m. Utility Charges for Service to Resistance Welders

CP. Fundamentals of Electric Rate Making.** *L. R. Lefferson*, Ebasco Services, Inc.

CP. Utility Metering of Resistance Welding Loads.** *M. A. Fawcett, C. A. Keener*, University of Illinois

CP. Why Special Utility Charges for Resistance Welders?** *R. E. Young*, Public Service Company

CP. A High-Output-Low-Demand Resistance Welding Machine.** *R. S. Phair*, The Budd Company

53-296. Design of Transformers for Resistance Welding Machines. *D. L. Knight*, National Electric Welding Machines Company. Re-presented for discussion

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Operations Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

** CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

1:30 p.m. Section Delegates Conference

1:30 p.m. Management

CP. An Outline of the Principles, Skills, and Tools of Management.** *R. M. Besse*, The Cleveland Electric Illuminating Company

CP. Engineering Economy as a Tool of Management.** *E. D. Ayres*, Ohio State University

1:30 p.m. Binaural Broadcasting

CP. Binaural Transmission by Frequency-Modulation Multiplex.** *M. G. Crosby*, Crosby Laboratories

CP. Stereophonic Recording Equipment.** *R. J. Tinkham*, Ampex Electric Corporation

CP. Better Realism With Binaural Sound Reproduction.** *H. T. Sherman*, Sherman Studios

CP. Engineering and Subjective Aspects of the Binaural Medium.** *E. Cook*, Cook Laboratories

1:30 p.m. Electron Tubes

CP. A New Ultrahigh-Frequency Amplifier Tube.** *Byron Stokes*, Sylvania Electric Products, Inc.

CP. A Monoscope Tube for Computer and Other Appliances.** *John Hartmann*, Allen B. Du Mont Laboratories, Inc.

53-307. Heat Transfer From Electron Tubes at High Altitudes and High Ambient Temperatures. *Mrs. B. O. Buckland*, General Electric Company

1:30 p.m. Instruments and Measurements

53-291. Preliminary Development of a Magnettor Current Standard. *E. P. Felch*, Bell Telephone Laboratories, Inc.; *J. L. Potter*, Rutgers University

53-292. A Commutatorless D-C Tachometer. *A. R. Eckels, W. R. Peck*, University of North Carolina

53-293. An Automatic Transfer Function Measuring and Recording System. *R. J. Ehret, E. F. Hochschild, J. M. Embree, E. C. Grogan*, Minneapolis-Honeywell Regulator Company

CP. A Small Aircraft Instrument Servomotor.** *L. T. Akeley, J. R. Macintyre*, General Electric Company

1:30 p.m. Insulated Conductors

53-228. A Critical Soil Moisture Condition Affecting Buried Transmission Cables. *W. A. Hadley, R. Eisenstadt*, Columbia University

53-230. A Simplified Mathematical Procedure for Determining the Transient Temperature Rise of Cable Systems. *J. H. Neher*, Philadelphia Electric Company

53-214. Tests of Fittings on Insulated Aluminum Cable. *Joel Tompkins, E. K. Lanctot*, Aluminum Company of America. Re-presented for discussion

Wednesday, June 17

9:00 a.m. Land Transportation

53-264. Controlling D-C Arcs. *R. L. Hurtle*, General Electric Company

CP. Service Performance of New Trolley Coach Equipment.** *B. F. Krings*, Westinghouse Electric Corporation

CP. Trolley Coach Versus Motor Coach—Here's 15 Years of Competitive Operating Costs.** *L. W. Birch*, Ohio Brass Company

9:00 a.m. Switchgear

CP. An Analysis of an Analogue Solution Applied to the Heat Conduction Problem in a Cartridge Fuse.** *A. E. Guile*, Queen Mary College, University of London; *E. B. Carne*, Remington Rand, Inc.

53-212. Testing Inhibited Oils in Circuit Breakers. *W. M. Leeds*, Westinghouse Electric Corporation; *R. F. Seubert*, Koppers Company, Inc.

53-231. Features of the Philadelphia Switchgear Development Laboratory. *W. F. Skeats, R. L. Williams*, General Electric Company

9:00 a.m. Insulation of Rotating Machinery

53-301. Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue. *C. J. Herman*, General Electric Company. Re-presented for discussion

53-207. A Method of Evaluating Insulation Systems in Motors. *C. B. Leape, J. McDonald, G. P. Gibson*, Westinghouse Electric Corporation. Re-presented for discussion

CP. The Evaluation of Class H Motor Insulation Systems.** *J. F. Dexter, E. Earleywine*, Dow-Corning Corporation

CP. Aging Effects on Insulation Resistance at High Temperatures.** *J. L. Fuller, P. H. Kahelin*, Reliance Electric and Engineering Company

CP. Effect of Voltage and Vibration on Insulation.** *A. T. McClinton*, Naval Research Laboratory

CP. Statistical Analysis in Functional Evaluation of Insulation.** *John Cybulski*, Naval Research Laboratory

9:00 a.m. Magnetic Recording

CP. Present Status of Magnetic Recording.** *R. E. Zenner*, Armour Research Foundation

53-300. Synchronized Magnetic-Tape Recording. *R. H. Ranger*, Rangertone, Inc.

CP. Structure and Performance of Magnetic Transducer Heads.** *L. L. Anderson, O. Kornei*, Brush Development Company

CP. Performance Characteristics of Ferrite Recording Heads.** *J. F. Jewett*, Ferroxcube

9:00 a.m. Electronic Systems Reliability

53-208. Reliability in Industrial Electronic Equipment. *E. D. Cook*, General Electric Company

CP. The Human Being in Man-Machine Systems.** *F. R. Naka*, Massachusetts Institute of Technology

CP. Equipment Reliability as Applied to Analogue Computers.** *Herbert Jacobs, Jr.*, Massachusetts Institute of Technology

CP. Achieving Higher Reliability and Accuracy From Electronic Components by Utilizing Components in Parallel.** *P. B. Montgomery*, Goodyear Aircraft Corporation

9:00 a.m. Nucleonics and Power Generation

CP. Major Factors in the Approach to Atomic Power.** *B. R. Prentice, R. G. Lorraine*, General Electric Company

CP. The Nature of Nuclear Power.** *J. W. Landis*, Atomic Energy Commission

CP. Nuclear Reactors for Power Generation.** *R. L. Witzke, J. M. Stein, E. U. Powell*, Westinghouse Electric Corporation

CP. Considerations for Discontinuous-Type Power Regulation of Nuclear Reactors.** *J. M. Harrer*, Argonne National Laboratory

CP. A Photomultiplier Log Level Period Meter for Reactor Control.** *V. G. Shaw*, Westinghouse Electric Corporation

CP. Maintenance Problems With Reactor Auxiliaries and Instruments.** *C. B. Wagner*, General Electric Company

9:00 a.m. Instruments and Measurements

53-294. Generator Stator Copper Temperature Indicator. *A. L. Brownlee, H. E. Brown*, Commonwealth Edison Company

53-205. Integrating Instruments for Simplified Quality-Control Measurements. *D. M. Longenecker*, General Electric Company

53-295. Correction of Frequency Errors in Wattmeters. *J. R. Freeman*, Massachusetts Institute of Technology

CP. Designing a Line of D-C Portable Instruments.** *R. M. Rowell*, General Electric Company

1:30 p.m. Transistor Standardization

1:30 p.m. Switchgear

53-309. Bushing Current Transformers for Oil Circuit Breakers. *R. B. Shores, C. E. Wollerton*, General Electric Company

53-232. Considerations in the Operation of Outdoor Oil Circuit Breakers Under Low Ambient Temperatures. *E. B. Rietz*, General Electric Company

53-233. Hydraulic Operating Mechanisms for High-Capacity Circuit Breakers. *E. E. Briggs, R. D. Hambrick, D. M. Umphrey*, Pacific Electric Manufacturing Corporation

53-234. A New Compressed Air Circuit Breaker for Arc Furnace Switching Duty. *J. E. Schramek, J. K. Walker*, Westinghouse Electric Corporation

1:30 p.m. Rotating Machinery

53-302. Calculation of No-Load Waveshape of Salient-Pole A-C Generators. *D. Ginsberg, A. L. Jokl*, Engineer Research and Development Laboratories; *L. M. Blum*, National Bureau of Standards

53-303. Factory Testing of Large Turbine-Generators. *R. W. Stevens, M. D. Ross*, Westinghouse Electric Corporation

53-304. D-C Dynamic Braking of Squirrel-Cage Induction Motors. *W. La Pierre*, Columbia University; *N. Metaxas*, Athens and Pireus Electricity Company

53-305. Commutation of Low-Voltage D-C Aircraft Generators. *P. W. Franklin*, Consultant, Naval Air Development Center. Re-presented for discussion

53-306. Leakage-Voltage Characteristics of Insulation Related to D-C Dielectric Strength. *J. S. Johnson, J. W. Clokey*, Westinghouse Electric Corporation. Re-presented for discussion

1:30 p.m. Special Communications Applications

53-202. Automatic Control System With Provision for Scanning and Memory. *N. H. Young*, Federal Telecommunication Laboratories, Inc.

CP. A Carrier-Type Magnetic Tape Recorder.** *L. L. Fisher*, Ampex Electric Corporation

CP. Graphic Analysis of Communications Networks.** *R. L. Mayer*, Pacific Gas and Electric Company

1:30 p.m. Nucleonics and Power Generation

CP. Precision Controls for a Low-Power Research Reactor.** *C. W. George, J. L. Matrone*, General Electric Company

CP. A Simple Electrical Analogue to a Nuclear Power Plant.** *J. N. Grace*, Westinghouse Electric Corporation

CP. Direct Linear Motion in Sealed Systems.** *R. C. Robinson, W. E. McCown*, Westinghouse Electric Corporation

CP. Position Control in Sealed Systems.** *W. H. Esselman, W. H. Hamilton*, Westinghouse Electric Corporation

CP. Present Feasibility of a Nuclear Power Plant.** *T. G. Le Clair*, Commonwealth Edison Company

1:30 p.m. System Engineering

CP. Austrian Power Supply.** *E. J. Schubert-Drinawehr*, Salzburg, Austria

53-255. Tensorial Analysis of Integrated Transmission Systems—IV. The Interconnection of Transmission Systems. *Gabriel Kron*, General Electric Company

53-256. Analysis of Losses in Loop-Interconnected Systems. *A. F. Glimn, L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Gas and Electric Service Corporation

53-209. Loss Formulas Made Easy. *A. F. Glimn, R. Habermann, Jr., L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Gas and Electric Service Corporation

CP. Economic Aspects of European Electric Power Development.** *P. A. Abetti*, General Electric Company

1:30 p.m. Carrier Current

53-204. Series-Resonant Circuits for Carrier Trapping of Resonant Taps. *S. Lubin, N. M. Levinson*, Sprague Electric Company

53-282. Telecommunication Equipment for Power Systems. Developments and Application in Sweden. *U. Hecht*, Allmänna Svenska Elektriska Aktiebolaget; *S. Rodhe*, Telefonaktiebolaget L. M. Ericsson; *H. J. B. Nesvitt*, Ericsson Telephone Sales Corporation

CP. Operation of Single-Sideband Power-Line Carrier.** *P. Taylor*, Central Light and Power Company; *B. M. Ray*, Westinghouse Electric Corporation

CP. New Carrier-Current Telephone Equipment for Modern Electrical Utility Communications.** *Paul Crooker*, General Electric Company

CP. Experience and Reliability of Carrier Relaying Channels.** *Carrier Current Project Subcommittee 5*

Thursday, June 18

9:00 a.m. Electrical Safety Standards and Practices

CP. Edison Electric Institute, National Safety Council, American Society of Safety Engineers.** *W. F. Brown*, Consolidated Edison Company of New York, Inc.

CP. National Electrical Manufacturers Association, AIEE.** *H. H. Watson*, General Electric Company

CP. American Standards Association, Canadian Standards Association, National Bureau of Standards.** *W. C. Wagner*, Philadelphia Electric Company

CP. Underwriters' Laboratories, Inc., National Fire Protection Association, National Board of Fire Underwriters.** *Karl Geiger*, Underwriters' Laboratories, Inc.

9:00 a.m. Magnetic Amplifiers

53-283. A Transient Analyzer for Magnetic Amplifiers. *E. J. Smith*, Polytechnic Institute of Brooklyn

53-284. Theory of Magnetic Amplifiers With Square-Loop Core Materials. *H. F. Storm*, General Electric Company

53-215. Problems to Consider in Applying Selenium Rectifiers. *J. Gramels*, Bell Telephone Laboratories, Inc.

53-285. An Application of Magnetic Amplifier Circuits to Perform Multiplication and Other Analytical Operations. *L. A. Finzi, R. A. Mathias*, Carnegie Institute of Technology. Re-presented for discussion

9:00 a.m. Wire Communications

53-221. The L3 Coaxial System. *C. H. Elmendorf, R. D. Ehrbar, R. H. Klie, A. J. Grossman*, Bell Telephone Laboratories, Inc.

53-222. L3 Coaxial System—Amplifiers. *L. H. Morris, G. H. Loedl, F. R. Dickinson*, Bell Telephone Laboratories, Inc.

53-223. L3 Coaxial System—Equalisation and Regulation. *R. W. Ketchledge, T. R. Finch*, Bell Telephone Laboratories, Inc.

53-224. L3 Coaxial System—Television Terminals. *J. W. Ricks, R. S. Graham*, Bell Telephone Laboratories.

CP. Compandors for General Use on Wire and Radio.** *R. S. Caruthers*, Lenkurt Electric Corporation

9:00 a.m. Power Generation, Station Design

CP. Modern High-Capacity Steam Generator Protection.** *J. A. Elzi, J. C. Bates*, Commonwealth Services, Inc.

CP. Electrical Safety Features Used for Boiler Protection in Several Large Generating Stations in the Southeast.** *A. H. Mergenthaler*, Southern Services, Inc.

CP. Boiler Protection and Interlocking on the American Gas and Electric System.** *H. C. Barnes*, American Gas and Electric Service Corporation

CP. Operating Protection Devices for a Reheat Pressurized Boiler.** *G. R. Hahn*, Consolidated Edison Company of New York, Inc.

CP. Electrical Safety Features Used for Boiler Protection at Delaware Station.** *E. E. Brown*, Philadelphia Electric Company

9:00 a.m. High-Dielectric-Constant Ceramics

53-235. Dielectric Breakdown of Sulphur Hexafluoride in Nonuniform Fields. *C. N. Works, T. W. Dakin*, Westinghouse Electric Corporation. Re-presented for discussion

53-236. The Effect of Minor Constituents in High-Dielectric-Constant Titanate Capacitors. *W. W. Coffen*, Metal and Thermit Corporation

CP. Tailoring Ceramic High-K Dielectrics for Specific Applications.** *R. J. Dew, Jr.*, American Lava Corporation

CP. High-K Ceramic Dielectrics Made From Zirconate and Titanate Materials.** *Shelton, Bunting, Kepball*, National Bureau of Standards

CP. New Developments in Ceramic Dielectrics for Capacitors.** *A. K. Das Gupta, K. R. Clark, S. Heidelman*, Solar Manufacturing Corporation

9:00 a.m. Electronic Circuit Principles

CP. Some Physical Considerations in the Analysis of Transistor Transient Response.** *J. J. Suran*, General Electric Company

CP. Temperature-Stabilized D-C Amplifier Employing Junction Transistors.** *Edward Keonjian*, General Electric Company

CP. Wide Deviation Frequency-Modulated Oscillator.** *D. J. Gray, V. P. Gurskis, W. E. Morrow*, Massachusetts Institute of Technology

CP ** Analysis of Power-Distributed Amplifiers. *P. H. Rogers*, University of Michigan

9:00 a.m. Electronic Instruments

53-298. A Universal Meter for Measuring Voltages at High Impedances, Micromicroamperes, and Insulation Resistance. *W. R. Clark, R. E. Watson, G. C. Mergner*, Leeds and Northrup Company

53-308. Vacuum-Tube Voltmeter Concepts in the Mid-Frequency Range. *G. B. Hoadley*, North Carolina State College

53-244. A-C Null-Type Recorder With Balancing Amplifier Which Provides Damping and Suppresses the Quadrature Component. *A. J. Williams, Jr., J. F. Payne, Jr.*, Leeds and Northrup Company

CP. Design Criteria for Mutual Inductance Micrometers.** *H. Joseph*, National Bureau of Standards

CP. Sheet and Plated Metal Measurements With a Phase-Angle-Type Probe.** *W. A. Yates, J. L. Queen*, National Bureau of Standards

1:30 p.m. Magnetic Amplifiers

CP. Frequency and Temperature Insensitive Regulated Power Supplies.** *M. A. Pahlavan*, INET, Inc.; *A. B. Rosenstein*, University of California

CP. Design Considerations of the Half-Wave Bridge Magnetic Amplifier.** *C. W. Lufcy, H. H. Woodson*, United States Naval Ordnance Laboratory

CP. Magnetic Amplifier Servo Compensation.** *H. H. Woodson*, United States Naval Ordnance Laboratory

CP. An Application of Compensated Half-Wave Bridge Magnetic Amplifiers.** *E. T. Hooper*, United States Naval Ordnance Laboratory

1:30 p.m. Wire Communications

53-203. Protection of Wire Communication Facilities Serving Power Stations and Substations. *T. W. Alexander*, Bell Telephone Company of Pennsylvania

53-225. Co-ordination of M1, N1, and O1 Telephone Carrier Systems. *E. P. Smith, L. P. Cornell, Jr., M. G. Jerome*, Pacific Telephone and Telegraph Company

53-226. The Control of Noise and Crosstalk on N1 Carrier Systems. *A. J. Aikens*, Bell Telephone Laboratories, Inc.; *C. S. Thaeler*, American Telephone and Telegraph Company

53-227. Transmission Design of Intertoll Telephone Trunks. *H. R. Huntley*, American Telephone and Telegraph Company

1:30 p.m. Power Generation, Hydroelectric Systems

53-220. Unique Outdoor Hydroelectric Plant. *H. E. Rhoades*, Northern States Power Company

CP. Important Economic Factors in the Development of Rehabilitation of Small-Capacity Hydroelectric Stations.** *H. H. Brown*, Wisconsin Michigan Power Company; *A. R. Klann*, Allis-Chalmers Manufacturing Company

CP. Progress Report by the AIEE Joint Subcommittee on Application Probability Methods to Power System Problems, Power Generation, and System Engineering**

1:30 p.m. Magnetics

53-259. The Permeability of Silicon-Iron at Very Low Flux Densities. *Eberhard Both*, Fort Monmouth, N. J. Re-presented for discussion

53-260. Stressed Ferrites Having Rectangular Hysteresis Loops. *H. J. Williams, R. C. Sherwood, Matilda Goerts, F. J. Schnettler*, Bell Telephone Laboratories, Inc. Re-presented for discussion

53-261. Mathematical Description of Core Losses. *J. W. Hale*, Allegheny Ludlum Steel Corporation; *F. R. Richardson*, General Electric Company. Re-presented for discussion

1:30 p.m. Transformers

53-275. Analytical Approach to the Variable Turns-Ratio Autotransformers. *E. Mishkin*, Hebrew Institute of Technology, Israel

CP. Measurement of Ambient Air Temperature During Temperature Test on Transformers.** *M. F. Beavers*, General Electric Company

53-270. Analysis of the Delta Grounded Transformer. *E. T. B. Gross*, Illinois Institute of Technology; *K. J. Rao*, Vern E. Alden Company

CP. Modern Forced-Air Cooling of Power Transformers.** *W. D. Albright*, Westinghouse Electric Corporation

53-276. Special 3-Phase Core Arrangements. *F. C. Roeding*, Westinghouse Electric Corporation

2:00 p.m. Instruments and Measurements

53-289. Forcing Function Generator Employing Conductive Plastic. *L. W. Norman*, Minneapolis-Honeywell Regulator Company

53-290. A Permeability Analyzer for Magnetic Amplifier Cores. *Philip Siskind*, Sperry Gyroscope Company

CP. Basic Theory and Experimental Verification of the A-C Galvanometer.** *T. J. Higgins*, University of Wisconsin; *William Knoen*, Pullman Corporation

CP. An Emission Characteristic Plotter for Thermionic Cathodes.** *Lewis Marzetta*, National Bureau of Standards

Friday June 19

9:00 a.m. Communication Switching

53-216. An Application of Boolean Algebra to the Design of Electronic Switching Circuits. *S. H. Washburn*, Bell Telephone Laboratories, Inc.

53-217. The Map Method for Synthesis of Combinational Logic Circuits. *M. Karnaugh*, Bell Telephone Laboratories, Inc.

CP. Circuit Action Charts.** *A. C. Reynolds*, International Business Machines Corporation

53-218. Transistors and Their Circuits in the 4A Toll Crossbar Switching System. *P. Mallery*, Bell Telephone Laboratories, Inc.

53-219. Telephone System Applications of Recorded Machine Announcements. *W. Bennett*, Bell Telephone Laboratories, Inc. Re-presented for discussion

9:00 a.m. Transformers

CP. Crepe Papers and Crepe-Paper Cables for Transformers.** *G. Camilli, L. Mulligan, E. L. Crandall*, General Electric Company

53-277. A New Low-Liquid-Content Current Transformer. *L. W. Marks*, General Electric Company

CP. External and Internal Factors Affecting High-Voltage Bushing Withstand Values.** *S. Terpak, D. L. Johnston*, General Electric Company

53-278. An Impulse Generator Circuit for Chopped-Wave Tests on Transformers. *G. H. Johnson*, Line Material Company

9:00 a.m. Transmission and Distribution

53-229. Physical Concepts of Corona in Capacitors. *J. R. Nye*, General Electric Company

53-257. Puncture Tests on Porcelain Distribution Insulators Using Steep-Front Voltage Surges. *J. H. Park, H. H. Conet*, National Bureau of Standards

CP. Field Report on a New Surge-Test Oscillograph.** *W. G. Fockler*, Allen B. Du Mont Laboratories

53-258. Economic Merits of Secondary Capacitors. *R. A. Zimmerman*, Westinghouse Electric Corporation

9:00 am. Basic Science

53-262. The Electric Strength of Air in Nonuniform Fields at Radio Frequencies. *J. B. Whitehead, C. F. Miller,* The Johns Hopkins University; *D. L. Birx,* The Franklin Institute Laboratory for Research and Development

53-263. The Electron Ion Recombination Process in Gases. *Sidney Borowitz,* New York University. Re-presented for discussion

CP. Tracking Response Characteristics of the Human Operator.** *J. I. Elkind,* Massachusetts Institute of Technology

53-265. Applications of Integral Equations to the Solution of Nonlinear Electric Circuit Problems. *L. A. Pipes,* University of California

53-266. Flow of Energy in D-C Machines. *E. I. Hawthorne,* University of Pennsylvania

9:00 a.m. Power Generation, Prime Movers

CP. Methods of Starting Gas Turbine-Generator Units.** *W. B. Boyum, R. W. Ferguson, J. G. Partlow,* Westinghouse Electric Corporation

CP. Can Human Engineering Help in Reaching Decisions in Instrumentation and Control?** *B. J. Cosner,* Dunlap and Associates, Inc.

CP. Generating Plant Costs in 1952.** *A. E. Knowlton, Electrical World* Magazine

9:00 a.m. Petroleum Industry

CP. Modern Electric Distribution System for an Oil Refinery.** *V. Nealy,* Texas Company

CP. Design Factors of Refinery Electric Distribution.** *H. G. Buch,* Socony Vacuum Company

CP. Turbogenerators and Heat Balance of Refinery Applications.** *J. C. Spahr,* Westinghouse Electric Corporation

CP. High-Voltage Motor Control for Semi-hazardous Locations.** *Ray Maynard,* General Electric Company

CP. Motor Lubrication Practices in an Oil Refinery.** *F. H. Walker,* Atlantic Refining Company

9:00 a.m. Transient Response of Systems

53-247. A Relative Damping Criterion for Linear Systems. *J. F. Koenig,* National Bureau of Standards

53-248. Approximation of Transient Response From Frequency Response Data. *C. H. Dawson,* University of Rochester

53-249. The Synthesis of Optimum Transient Response: Criteria and Standard Forms. *Dunstan Graham, R. C. Lathrop,* Wright Air Development Center

53-250. Bibliography on Feedback Control, Part I. *Subcommittees on Bibliography of the Committees on Industrial Control and Feedback Control Systems*

53-251. Bibliography on Feedback Control, Part II. *Subcommittees on Bibliography of the Committees on Industrial Control and Feedback Control Systems*

1:30 p.m. Radio Communications

53-198. Frequency Generating Equipment for Million-Watt Navy Transmitter. *D. G. Robertson,* Radio Corporation of America

53-199. A Million-Watt Naval Communication Transmitter. *J. C. Walter,* Radio Corporation of America

53-196. Aircraft Protection From Thunderstorm Discharges to Antennas. *J. M. Bryant,* University of Minnesota; *M. M. Newman, J. D. Robb,* Lightning and Transients Research Institute

53-213. The New Jersey Turnpike—A Unique Highway Communication System. *P. F. Godley,* Paul Godley Company; *J. R. Neubauer, D. R. Marsh,* Radio Corporation of America. Re-presented for discussion

1:30 p.m. Transformers

53-246. Temperature Classes for Dry-Type Transformers as Determined by Functional Tests. *Paul Narbut,* Westinghouse Electric Corporation

53-243. Life Expectancy of Oil-Immersed Insulation Structures. *W. A. Sumner, G. M. Stein, A. M. Lockie,* Westinghouse Electric Corporation

53-279. Field Theory of Wave Propagation Along Coils. *H. Poritsky, P. A. Abetti, R. P. Jerrard,* General Electric Company

53-245. Sealed Dry-Type Transformers Proved Safe by Test. *E. W. Tipton,* Westinghouse Electric Corporation

53-280. Propagation Mechanism of Impulse Corona and Breakdown in Oil. *T. W. Liao, J. G. Anderson,* General Electric Company

1:30 p.m. Nonlinear Systems

53-252. Optimization of Nonlinear Control Systems by Means of Nonlinear Feedbacks. *R. S. Neiswander, R. H. MacNeal,* California Institute of Technology

53-253. Open-Loop Frequency Response Method for Nonlinear Servomechanisms. *R. L. Cosgriff,* Ohio State University

53-254. Describing Function Method of Servomechanism Analysis Applied to Most Commonly Encountered Nonlinearities. *H. D. Greif,* Hughes Aircraft Company

CP. The Finger-Type Voltage Regulator.** *T. F. McHenry,* Electric Regulator Corporation

1:30 p.m. Basic Science

53-267. The First-Order Behavior of Separable Oscillators. *D. C. Depackh,* Naval Research Laboratory

CP. Acceleration Plane Method for Analysis of a Circuit With Nonlinear Inductance and Nonlinear Capacitance.** *Y. H. Ku,* Moore School of Electrical Engineering

53-268. Basic Concepts in the Analysis of Stationary Electric Circuits. *D. W. Spence, C. R. Cahn,* Niagara Mohawk Power Corporation

53-269. Block Diagram Solutions for Vacuum-Tube Circuits. *T. M. Stout,* University of Washington. Re-presented for discussion

Southern District Meeting in Louisville Includes Annual Appliance Conference

True to its traditional hospitality, the AIEE Southern District provided excellent fare—both technical and social—to the 457 members and guests who attended its meeting in the Seelbach Hotel, Louisville, Ky., April 22–24. A number of inspection trips were taken to near-by industries, power plants, and Station *WHAS-TV*. A total of 15 sessions were held during the 3 days. In conjunction with the District Meeting, the fourth annual Technical Conference on Appliances was held.

GENERAL SESSION

Professor M. G. Northrop, General Chairman of the meeting, welcomed the members at the general session in the ballroom on Wednesday morning. He introduced George Hendon, the executive assistant to Mayor C. P. Farnsley of Louisville, and after extending a warm welcome to the members, he presented AIEE President D. A. Quarles with a miniature flag of the city and the traditional key. After acknowledging the welcome, Mr. Quarles spoke on several matters of interest to the Institute on a national level. (Mr. Quarles' address will be found on pages 477–9.)

The Vice-President of District 4, E. S. Lammers, Jr., next addressed the members on "Engineers in the Making."

He first paid tribute to the far-sighted Institute members of 1903 who started the student activities. "Those men were wise," he said, "because they realized that the AIEE would need engineers in future years just as the engineers need the Institute; one supplements the other."

He pointed out that there are two fundamentals that make engineers of the future: the facilities of a college—its laboratories, classrooms, proper guidance, and so forth; and the laboratories of industry, where engineers can become familiar with the equipment of engineering. The acquisition of funds to provide these fundamentals constitutes a major problem.

In this respect, District 4 has held its own in producing engineers. It has 18 of the 132 Student Branches of the Institute, and during the last 4 years, twice has won the National Branch Paper Prize.

According to Mr. Lammers, one factor should never change in the making of an engineer: the desire to create and to contribute his best efforts. Engineers cannot be measured as can an assembly line; their engineering life is like a ladder based on the heritage of the past up which they must climb to its top at the pinnacle of success.

F. W. Russell, vice-president in charge of operation, Louisville Gas and Electric Company, discussed the "Recent Power Expansion in the Louisville Area." In 1930 there was but one steam power plant, but since World War II generating capacity in the area has increased 500 per cent over what it was 23 years ago. Mr. Russell described the expansion of the interchange of power and the 154,000-volt lines to the Tennessee Valley Authority, over which last year more than 1,000,000,000 kilowatt-hours went south through the Paddy's Run Terminal. The speaker told how the Louisville company is tied in with the newly formed Ohio Valley combine and about the tests and developments of its projects.

Mr. Russell addressed his closing remarks to the hundred or more students at the meeting, saying that they could not have chosen a better profession and urging them to consider opportunities in the power field.

SOCIAL EVENTS

At a luncheon following the general session, Keen Johnson, former Governor of Kentucky, drew from his vast store of amusing stories in his talk on the increased use of aluminum in today's electrical engineering field and tomorrow's opportunity in power.

On Wednesday evening a reception for members, guests, and students was held followed by a buffet supper and a floor show. The following evening a banquet and dance was enjoyed by members and guests. It was at the banquet that the Student paper awards were made by Vice-President Lammers.

INDUSTRY SESSIONS

Two industry sessions were held with Frank P. Lederer presiding at the first and Mead Warren presiding at the second of these sessions.

In the first session, F. P. Brightman, General Electric Company, outlined the various steps which should be taken to

Pacific General Meeting Site

Vancouver, British Columbia, will be the scene of the AIEE Pacific General Meeting, September 1–4, 1953. Third largest city in Canada, Vancouver is located 15 miles due north of the International Boundary and approximately 140 miles north of Seattle, Wash. The city is built on one of the world's finest natural harbors with spectacular mountain and seascape background. Here, looking north across the harbor to the North Shore mountains, can be seen the Lions' Gate Bridge, longest suspension bridge in the British Empire, and the wooded area of Stanley Park, 1,000 acres of unspoiled forest. The largest building, left center, is the Hotel Vancouver, headquarters for the AIEE meeting

obtain relay co-ordination in industrial plants. The author concluded that operators would profit greatly from making the necessary systems studies. Another paper, which dealt with precise speed control over a wide range of 35 to 117 cycles in a variable-frequency drive for synthetic fiber spinning machines, was presented by Harry Stiltz of the E. I. du Pont Company. A reluctance type of synchronous motor is employed here with intricate control circuits. Still another paper in the field of textiles described several applications of electronic equipment for speed control, counting, and dielectric heating for drying. The author, Robert Posey of the Westinghouse Electric Corporation, cautioned against the use of electronic equipment if good standard industrial equipment is available because the maintenance of electronic equipment requires trained personnel.

Two of the papers were mathematical in nature. J. A. Granath and A. K. Hawkes, in a paper on power equalizer systems for aircraft alternators, worked out analytical expressions for the voltage and frequency in a 400-cycle system where real and reactive load division are accomplished by equalizer systems. The expressions enable the prediction of regulated quantities during an unbalanced condition on a more precise quantitative basis than has been possible heretofore. In the other paper, W. A. Stein of the United States Naval Postgraduate School derived formulas for determining rotor resistance and leakage reactance in reference to the stator winding for a drag-cup servomotor.

Another paper dealt with the advantages of multitransformer welding presses in the mass production of large fabricated parts.

In the second industry session, most of the papers were related to applications in mining work. Such problems as alternating versus direct current for underground mining, the electrical hazards of coal mining, and the technical aspects of electric equipment applications in coal preparation plants were discussed. Other papers dealt with outdoor motor enclosures, the grounding of industrial power systems, and a mechanism for the fuse prearcing period.

POWER

In the field of power, 11 papers were presented in two sessions which dealt with a broad variety of problems, such as the economics of fan cooling of transformers, the measuring and recording of small voltage variations produced by variable loads, and the design of a dispatching office. Still other papers had to do with the shape-correction factors for calculating short-circuit forces of busses composed of double-channel conductors and the restraining of the repulsive forces in large duplex current-limiting reactors.

In the second power session, papers were presented concerning the skin-spiraling effects in stranded conductors, the results of operating experience with connectors for aluminum conductors, and a direct method for sag-tension calculations.

In another paper, the duty of expulsion-type lightning arresters for distribution systems was analyzed and in still two other papers, an ingenious method of current-transformer design was brought forth as well as improved current-transformer design made possible by the use of cold-rolled high-permeability steel and the proper application of high-strength paper insulation.

GENERAL

For those interested in culture and laboratory research, a session of five papers was offered on Thursday afternoon. The first two papers were concerned with the power-system test facilities and electric equipment in the Arnold Engineering Development Center. Another paper described the new features incorporated in the new electrical engineering laboratories at the University of South Carolina. Two other papers treated electric power as a creative force in North Carolina and education and training for a living.

COMMUNICATIONS AND ELECTRONICS

In these fields, three sessions were held; W. J. Worthman presided over the first, J. L. Fulmer presided over the second, and Stuart Gates was chairman of the third.

In the first session, William Dodson of the American Air Filter Company presented three methods for the measurement of space charge. In a paper by Dean E. A. Walker and J. E. Coolidge, Jr., the laboratory results of an electrostatic precipitation study were presented. In another paper, T. L. Wilson of the Girdler Corporation outlined the numerous design problems in the development of dielectric heating equipment. Slides were shown of the polar pattern obtained when testing the effectiveness of shielding against radiation on installations which indicated results as low as 0.7 microvolt per meter at a distance of 1 mile. The Federal Communications Commission requires that radiation must be below 10 microvolts per meter at this distance.

In still another paper, by Shizuo Hori, Armour Research Foundation, and Professor T. J. Higgins, University of Wisconsin, exact numerical values were worked out for the capacitances of a coaxial, rectangular, cylindrical transmission line.

The development of an electronic multiplier capable of delivering an output voltage which is proportional to the instantaneous product of two alternating voltages was described in a paper by E. L. Peterson of Tulane University. The last paper, which discussed the influence of shunt capacitance variations upon the performance of self-saturating magnetic amplifiers, was presented by Chang Yun of the Allis-Chalmers Manufacturing Company.

In this second session on Communication and Electronics, C. A. Armstrong, American Telephone and Telegraph Company, read his technical paper, "Communications for Civil Defense." (A revised version of this paper will be found in the March 1953 issue of *Electrical Engineering*, pages 218–22.) H. L. Foote, Stromberg-Carlson Company, read "The XY Toll Ticketing System," which appears in this issue, pages 517–22.

Two District and three technical papers

were given at the third session. G. A. Holt, Atomic Energy Commission development engineer, presented the first District paper, "Design Criteria for Tube Aging and Tube Testing at Oak Ridge National Laboratory." After reviewing the vacuum-tube situation in the broadcast- and television-receiver fields today, the author stressed the necessity of having available tubes of much greater reliability for computers and nuclear-reactor control equipment. He described several "aging" circuits which have been used for the "screening" and aging of tubes before being used in vital instruments.

W. C. Burnett, Southern Bell Telephone Company, read the second District paper, "Radiotelephone From Wilmington to Shallotte, N. C." This paper dealt with the experience of the telephone company in adapting equipment of the mobile radiotelephone type to the provision of telephone service in a remote area of North Carolina which had none.

The first of the three technical papers, "Path Testing for Microwave Routes," was presented by R. D. Campbell, American Telephone and Telegraph Company. The author described methods for determining and testing the optimum locations of antennas for the transmission and reception of microwave signals and the interference effects of different types of terrain in the paths. (A revised version of this paper is scheduled for the July issue of *Electrical Engineering*.)

W. W. Macalpine, Federal Telecommunications Laboratory, presented a mathematical paper, "Computation of Impedance and Efficiency of Transmission Line With High Standing Wave Ratio," and the final technical paper, by E. G. and E. O. Gilbert, University of Michigan graduate students, was "A Capacitively Coupled Field Mapper for 2-Dimensional Distributed-Source Field Problems." By the use of a special paper, "Teledeltos," and an ingenious electronic circuit, the authors showed how a field of any configuration could be plotted with remarkable accuracy.

APPLIANCE TECHNICAL CONFERENCE

The opening session of the Appliance Conference, which had as its theme, "Appliance Control Components," was held on Wednesday afternoon in the Grand Ballroom. T. H. Cline, Chairman of the Committee on Domestic and Commercial Applications, in his welcoming remarks stated that this, the fourth annual Appliance Conference, was a continuation of last year's conference on controls inasmuch as the subject was so broad that much more remained to be discussed at the close of the third conference.

R. W. Gustafson, General Electric Company, read the first paper, "New Oil Burner Heat Control." A thermal timer type, this control's cost is low and it is adaptable to standard units and systems. It can be used with remote flame detection or built into the stack switch type of control. The transformer and relay are combined in one device; the thermal timer is enclosed and ambient compensated; and the flame detector is a simple clutch-operated device.

"Evaluation of Performance for Appliance Controls" was presented by G. C. Pearce, Frigidaire Division of General Motors Corporation. In this paper, the author discussed the various techniques which have been developed for testing timers for washers, ranges, and refrigerators; thermostats; and for the various components of appliances which showed too short a life.

V. V. Savolainen's paper, "Reversed Thermostat Metal," was read by R. M. Sears, General Plate Division, Metals and Controls Corporation. After a discussion of the properties of the metals and the methods of fabrication, the author described the various forms in which these thermostats are used in appliances.

Frank Spayth, P. R. Mallory Company, presented "Electrical Contacts." After enumerating the five basic contact problems—contact resistance, erosion, transfer, sticking or welding, and energy dissipation—the author discussed each one and then told about the different types of contacts.

The final paper of the session, "Fundamentals of Bimetal Performance," was presented by C. F. Alban, W. M. Chace Company, in which were given equations for calculating the properties of the thermostatic bimetals and their applications.

The second session of the Appliances Conference, at which T. T. Woodson was chairman, was opened by A. P. McNamee of *McCall's* Magazine, who spoke on "Kitchen Layout Studies." This was a résumé of a kitchen-designing contest in which more than 18,000 women expressed their preferences for kitchen appliances, furnishings, and arrangements.

A. B. BecVar, General Electric Company, presented "What Does Design Mean to the Customer?" Good design expresses good quality, good engineering, and easy sales, the final design of a product being a selection of ideas submitted by all the departments of a firm which have anything to do with the making and marketing of the product. Good design is a happy medium struck between lavishness and the aesthetic.

"Static Nonlinear Elements for Appliance Control" was read by B. H. List, coauthor with R. C. McMaster and R. L. Merrill, all of Battelle Memorial Institute. It was brought out that as appliance controls become more complex and more costly, the designer should consider static nonlinear elements, such as magnetic amplifiers, thermistors, transistors, germanium and silicon diodes, and dielectric amplifiers, which are finding increased use in many fields of electronics and industrial control.

The history of dishwashing machines over the last century was traced by G. H. Wotring, General Electric Company, in his paper "Dishwasher Controls." In 1918, an electric drive was added and 4 years later an automatic sequencing control was marketed. Mr. Wotring described the latest dishwasher controls and told of some of the unsolved problems.

The final paper of the session, "Grounding Plugs and Grounding of Appliances," was given by G. C. Mapelsden, General Electric Company. The author reviewed the present state of appliance grounding requirements together with the devices available and the reasons for grounding.

Role of Fuses, Circuit Breakers, and Thermal Overloads in Appliance Protection. The climax of the Appliance Technical Conference was a symposium in which papers by six experts presented the "Role of Fuses, Circuit Breakers, and Thermal Overloads in Appliance Protection." In the panel discussion which followed, M. M. Brandon, Underwriters Laboratories, Inc., acted as moderator.

The first paper, "Motor Overload Protection for Domestic Appliances," by W. H. Farrell of the Underwriters' Laboratories, served admirably as an introduction as it pointed out from an analysis of fires of electrical origin which occurred in 30 large cities throughout the United States in 1951 that 32.7 per cent of these fires were due to motor burn-outs. The author reviewed the conditions under which the Underwriters' Laboratories, Inc., has required thermal or overcurrent protection for motors in domestic appliances, conditions under which an appliance has been considered to be automatically controlled, conditions under which a hazard has been considered to exist, and new conditions in the appliance which may be introduced by the installation of an overload protective device. The specific applications where motor protection has been required on appliances were outlined.

The second paper, "Branch Circuit Overcurrent Protection for Appliance Loads," was presented by F. G. VonHoorn of the General Electric Company. The subject was discussed from the point of view of three typical types of branch circuits and their protective devices: 1. general-purpose lighting and appliance branch circuits; 2. special branch circuits supplying a single fixed appliance; and 3. motor branch circuits.

The third paper gave the results of a field survey of the role of inherent overheat protection in appliances and was presented by E. P. Jastram, Jr., Spencer Thermostat Division, Metals and Controls Corporation. A traveling laboratory which visited motor repair shops throughout the southern states made this extensive field survey. The results indicated that 80.2 per cent of all burned-out motors examined were without inherent protectors, 14.4 per cent of all burned-out motors had other makes of inherent protectors, and 5.4 per cent examined had Klixon inherent protectors. The authors concluded that field surveys to date indicate that inherent protectors reduce burn-outs among motors coming into repair shops by a factor of 80 per cent.

The fourth paper dealt with "Role of Fuses in Appliance Protection" and was presented by J. C. Lebens of the Bussman Manufacturing Company. The author discussed the characteristics of fuses and the selection of the proper type of fuse for the protection of the appliance and cord. Particular emphasis was laid on the time–current characteristics of the 100-ampere 250-volt dual-element fuse and the ordinary 1-time fuse. In conclusion, the author stated that the fuse manufacturers have available time–current characteristics of the various types of fuses they manufacture, which makes the selection of the proper fuse for a given appliance a relatively simple job.

The fifth paper was entitled "Miniature Fuses for Protection of Appliance Circuits" and it was presented by A. J. Steele of Littlefuse Inc. The author described the development of miniature fuses, and a comparison of the various types of fuses was drawn, as well as a comparison of miniature fuses and service circuit breakers. For discussion by the forum, the author recommended that inasmuch as the *3AB* fuse

must stand up under the same tests as branch circuit fuses, his company feels that the *3AB* fuse should be allowed the same privilege of application as the branch circuit fuses. If not allowed privileges of application comparable to branch circuit fuses, the author recommended that the test specification of Underwriters' Laboratories be made comparable to that of auxiliary or service-type circuit breakers.

The sixth paper, entitled "Overload and Overcurrent Protection of Motorized Appliances and Their Branch Circuits," was presented by G. W. Heumann of the General Electric Company. The author reviewed the causes of motor overheating, thermal overload relays, short-circuit protection, and he explained the design and tripping characteristics of the molded cased air circuit breakers.

Discussions. Among the many interesting questions raised, R. Fauquet, Sears Roebuck and Company, inquired as to the reason why automatic washing machines have been required to have overload protection only if the capacitor-type motor is employed. W. H. Farrell explained that capacitors were not always too reliable and that additional tests had been run. This requirement has been in effect for a considerable period of time.

In connection with automatic dishwashing machines, L. L. Miller, Bendix Home Appliances, suggested raising the 125-degree-centigrade temperature limit on motor windings under running overload conditions when 150 degrees centigrade protection had been put in against locked rotor conditions. G. C. Mapeladen of the General Electric Company pointed out that the automatic dishwasher would require this protection only if it could be demonstrated that the motor could be overloaded. J. C. Worst of the General Electric Company pointed out that the washing machine motor is protected by a clutch. L. Tulauskas of P. R. Mallory and Company explained that the manufacturer of the machine used a fluid coupling and Mr. Farrell explained that if there was no question of overload running that protection would not be required.

In respect to the point raised in Mr. Steele's paper for discussion to the effect that *3AB* fuses should be allowed the same privilege of application for branch circuit protection, M. Brandon of the Underwriters' Laboratories introduced the matter as follows: He explained that around 1900–1904 there was considerable confusion in the industry about the size of fuses and that Edison had developed an open-link fuse at that time. Every manufacturer had his own ideas about fuses so industry got together and developed an agreed-upon industry standard which was put in the code. The answer to the question was a matter of standardization which would have to go to the National Electrical Code Committee. J. C. Lebens of the Bussman Manufacturing Company stated that their position in the matter was that fuses beyond the 20-ampere sizes required special attention and when used in panelboard in the home, they would not receive that attention. T. H. Cline, Chairman of the Committee on Domestic and Commercial Applications, explained that there were many outlets in electric ranges where protection was provided by standard plug fuses which are difficult to find and reach and he expressed the belief that the ideal thing to use would be miniature fuses. He believed there should be some recognition for the use of these fuses in special applications.

STUDENT ACTIVITIES

Two well-attended student sessions were held in which 12 papers were presented by the students. The District Branch First Prize was awarded to H. W. Thompson, Jr., and S. H. Wesley, Jr., of North Carolina State College for their paper entitled "Problems in Crystal Manufacturing." The District Branch Second Prize was awarded to L. F. Goeller, Jr., of the University of Virginia for his paper entitled "Design of Broadcast Consolettes for Announcer Use." The awards were announced by Vice-President Lammers at the dinner on Thursday evening. The winners of the first prize will be entitled to a trip to the Summer General Meeting at Atlantic City, N. J., with expenses paid from the Members-for-Life fund.

A luncheon meeting of Student Branch Counselors was held on Thursday followed by a student business session on Friday morning. In addition to attending the evening social functions, many of the students also went on an inspection trip to General Electric Appliance Park. The papers presented at the two student sessions were as follows:

Student Sessions

Wednesday, April 22, 2:00 p.m.

Homopolar D-C Generator. *Hardy Ross Stone III*, Mississippi State College

Using the Oscilloscope for Accurate Phase-Angle Measurements. *W. C. Yengst*, Duke University

The Design of a Tick-Tack-Toe Machine. *J. L. Kaiser*, University of Kentucky

Problems in Crystal Manufacturing. *H. W. Thompson, Jr., S. H. Wesley, Jr.*, North Carolina State College

Power Generation From the Wind. *H. J. Boisseau, Jr.*, Tulane University of Louisiana

The Theory of Information and Its Application to Electronic Computers. *B. L. Simms, Jr.*, University of Louisville

Thursday, April 23, 9:00 a.m.

A Cathode-Ray Oscillograph for Recording Non-recurring High-Voltage Transients. *W. F. Sarles, Jr., J. R. Stewart, W. B. Wright*, Duke University

Quality Control of Electronic Components for Use in the Proximity Fuse. *Raymond Lorenzini*, Vanderbilt University

Design of Broadcast Consolettes for Announcer Use. *L. F. Goeller, Jr.*, University of Virginia

Determination of Temperature From the Velocity of Sound. *J. B. Hudson*, University of Kentucky

Photoelectric Complex-Wave Generator. *G. W. Magginson, T. R. Hudson*, University of Alabama

Voltage Analogues of Differential Equations. *D. V. Milton*, North Carolina State College

COMMITTEE

The chairmen of the Southern District Meeting Committee which made the arrangements were as follows: General, M. G. Northrop; Vice-Chairman, J. G. Lips; Secretary, Joseph D. Warren; Finance, W. J. Ryan; Registration, J. F. Gregory; Hotels, H. T. Smith; Equipment, T. W. Talcott; Entertainment, J. D. Caudill; Publicity, O. W. Towner; Transportation, R. D. Spaulding; Inspection Trips, W. B. Watkins; Student Activities, Professor S. T. Fife; Printing, J. M. Houchens; Sports, L. G. Weiser; Ladies, Mrs. J. G. Lips.

The chairmen of the Appliance Technical Conference committees were: Technical Program, T. T. Woodson; Finance, L. H. Gottliebsen; Registration, R. A. Rosenkrans; Equipment, S. B. Welch; Publicity, W. F. Kindt; Transportation, E. A. Zuercher; Inspection Trips, A. M. Anderson.

Boston Section Anniversary Highlights 1953 North Eastern District Meeting

The Golden Jubilee of the AIEE Boston Section was celebrated with a 3-day meeting at the Sheraton-Plaza Hotel starting on April 29 in the Hub City. Nearly 850 members and guests participated in the festivities and technical sessions. Concurrently with this North Eastern District Meeting was the Northern Textile Conference on May 1 at which the attendance was 70 members and guests.

Eleven technical sessions were on the program at which 30 papers were given; four papers were read at the Textile Conference; and at the Thursday morning General Session three addresses were enjoyed by the large audience. On Wednesday evening a cocktail party and dinner followed by vaudeville entertainment was enjoyed by the members and the following evening the banquet guests were addressed by A. C. Monteith, vice-president of the Westinghouse Electric Corporation, after which there was dancing.

The Western World must depend upon the engineer for its defense "because in manpower alone we are hopelessly outnumbered." Addressing the banquet guests, Mr. Monteith warned against an increasing shortage of engineering manpower and urged the intensification of programs to increase the supply of engineers. Americans must realize that a soldier in Korea is a "sitting duck" unless he is backed up with highly technical fighting tools, Mr. Monteith said. He emphasized that to provide these vital arms, "we must have strong, continuing programs of research and development."

To illustrate how short the supply of engineers is today, Mr. Monteith cited a report by the Survey Committee of Engineers Joint Council that a supply of about 30,000 graduate engineers is needed each year for normal industry operation, with another 12,000 required for defense needs. Of this total of 42,000 needed, the colleges are graduating about 21,000 this year—half of the number actually in demand. Although these figures summarize the shortage of engineers rather neatly, they do not show altogether the seriousness of the problem. For example, industry has a backed-up demand for more than 50,000 engineers today.

Furthermore, he said that there are indications that the number of engineering

graduates in future years will decline because of a number of factors in education such as the shortage of science teachers and the inadequate preparation of high-school students for engineering work.

The Westinghouse executive pointed out that there is "nothing startlingly new about these figures" on the acute shortage of engineers and that the engineering profession has been aware of it for some time. To combat the shortage, he declared, engineering societies and industry have joined together in a number of programs aimed at increasing the supply of engineers through better utilization of engineering talent, more scholarships, work-study plans, and the like.

The ladies were entertained by a varied program with trips to historic points of interest of which Boston has so many. At noon on Friday the members attending the all-day Textile Conference enjoyed a luncheon address by Robert Browning of Booz, Allen, and Hamilton.

Featured speakers at the General Session were Dr. Lawrence R. Hafstad, United States Atomic Energy Commission, and Karl T. Compton, Massachusetts Institute of Technology. Left to right are: Mr. Compton; F. B. Haeussler, General Chairman; C. A. Powel, and Dr. Hafstad

GENERAL SESSION

The General Session was held Thursday morning in the Ballroom and AIEE Past-President C. A. Powel, Massachusetts Institute of Technology, presided. He announced the North Eastern District (1) prize paper winners, awarded by the District Executive Committee. The first prize of $75 was awarded to P. A. Abetti for "Transformer Models for the Determination of Transient Voltages" and the second prize of $50 to J. T. Blake, D. W. Kitchin, and O. S. Pratt for their paper, "Microbiological Deterioration of Rubber Insulation."

Mr. Powel then read "A Tribute to Elihu Thomson," the meeting being on the centenary of Thomson's birth. The speaker traced Professor Thomson's association with the early days of the General Electric Company and the Massachusetts Institute of Technology of which he was acting president during 1920–22. Professor Thomson was the fifth AIEE president in 1889.

Dr. Lawrence R. Hafstad, Director of Reactor Development, United States Atomic Energy Commission, gave "A Progress Report on Atomic Power." After describing the basic chemistry involved in atomic fission and how 2,600,000 pounds of coal have the same energy content of 1 pound of uranium 235, he explained the functioning of a reactor and the problems which the engineer must overcome before an economical power reactor will be practical, as it is not feasible in its present stage.

Materials of which power reactors are built must stand temperatures between 1,000,000 and 10,000,000 degrees centigrade; they must not absorb neutrons, for example aluminum, stainless steel, and zirconium; and they must stand up under intense radiation. In a nuclear power plant, the coolant becomes radioactive and it is from this radioactive liquid that heat is extracted to furnish heat to the electric power plant boiler.

There is sufficient uranium in the world for a power program, but there is a question: By the time we can produce electricity economically by a breeder reactor will we have learned to use solar energy instead? It is impossible at present to foretell when nuclear reactors will become economically practical, as plutonium is a product along with the heat and the cost and value of plutonium being classified at present, we cannot estimate what its price will be in the future.

The final address of the meeting, "Nuclear Research: in Retrospect and Prospect," was made by Karl T. Compton, Corporation Chairman, Massachusetts Institute of Technology. The speaker traced briefly the history of radioactivity from its discovery in 1896 by Becquerel through Sir Ernest Rutherford's discovery in 1920 that hydrogen could be knocked out of nitrogen leaving oxygen by the bombardment of alpha particles emitted by radioactive substances, and up to the establishment of chain reaction in December 1942.

At the end of World War II, it was imperative that the United States maintain its sole control of atomic weapons and the methods by which they might be produced. Now the situation is different. We and our Canadian and British allies no longer have the monopoly of atomic weapons. Some of the provisions of our Atomic Energy Act have stood in the way of our co-operation with our allies and also in the way of entrance of private initiative into the atomic energy field. These changed situations suggest that the Atomic Energy Act be reviewed and amended to make it the most effective base for our security and national advantage in this field under the circumstances which exist now and in the foreseeable future. It is the consensus of people who are familiar with the field that there be a more realistic handling of the matter of secrecy in the atomic energy field and that there be an opportunity for incentives to private enterprise to become a participant in these developments.

TECHNICAL SESSIONS

Two District papers on transistors were presented Wednesday morning at a session over which W. F. Potter, New England Telephone and Telegraph Company, presided. "Basic Principles of Transistor Electronics" was given by M. Sparks and the second paper was given by R. L. Wallace, Jr., whose subject was "Transistors as Circuit Elements." Both speakers are with the Bell Telephone Laboratories, Inc. Mr. Sparks reviewed the chemistry of transference of electrons and ions in solids and explained how the impurities of germanium are important in the functioning of transistors; how at room temperatures electrons are freed in transistors the same as electrons are when emitted from a hot filament in a triode; and described the growing of germanium with aluminum and arsenic.

Mr. Wallace described the types of transistors used in various circuits and explained how the transistor's negative impedance characteristics are useful in oscillators. Illustrating how important transistors can be in miniaturization, he showed a 10.5-megacycle-band amplifier of 15 components in a 1/8-inch tube 1½ inches long and a frequency-modulated transmitter and microphone which was attached to his shirt collar and used during his talk.

At the Wednesday morning session on relaying, presided over by H. L. Goodridge, the use of microwaves for power-system protective relaying was advocated by H. W. Lensner, Westinghouse Electric Corporation, if certain conditions exist: 1. A line-of-sight path may be established; 2. The carrier spectrum is filled; 3. Losses at carrier frequencies are large; 4. There is an economic advantage.

As the number of channels required increases, a "break-even" point is reached, beyond which any additional channels can be provided for most economically by the microwave system.

George Steeb, Niagara Mohawk Power Corporation, presented an unconventional method of relay protection for a 100,000-kva transformer and generator, in the unit generator-transformer station system. The following criteria were considered in its design:

1. It must be simple, as such a protective scheme is more reliable, requires less material, is easier to check, is less expensive, and is less hazardous.

2. A study of possible fault conditions was made first; the electrical scheme then followed.

In the discussion on Mr. Steeb's paper, it was brought out that the more usual differential-relay system of protection uses single-purpose relays, which do not require setting. Mr. Steeb replied by the assertion that multiplicity of purpose was an advantage, providing back-up protection, short-circuit protection, and detection of series unbalance, without additional equipment.

W. C. Morris and L. E. Goff, General Electric Company, in their paper said that the ideal relay for generator protection against unbalanced faults is one which responds only to the negative-phase-sequence current, and whose time-current characteristic is parallel to, but slightly lower than, the heating characteristic of the machine. They developed such a relay

R. L. Wallace, Jr., (second from right) Bell Telephone Laboratories, explains a miniaturized transistor amplifier to General Chairman F. B. Haeussler (left), M. Sparks of the Bell Laboratories, and W. F. Potter (far right) of the General Advisory Committee

which would bring relay practice into line with the proposed revision to the rotating electric machinery standard concerned with short-circuit requirements. Questioned on whether imbedded resistance or vibration methods could not provide equal protection at less cost, they said that the negative-phase-sequence-overcurrent relay was best when a generator required individual protection.

Magnetic amplifiers, having a power range from thousands of kilowatts to a fraction of a microwatt, have developed so rapidly since the last war that they now rival the electron tube itself in many applications, Dr. T. S. Grey, Massachusetts Institute of Technology, chairman of the session, said in his introduction.

Dr. E. L. Harder, speaking about power controllers, stated that the requirements of a regulating device to control the mass production of quality products were: 1. High gain and very fast response; 2. Very simple construction; 3. Rugged, reliable, and long-lived construction; 4. Infrequent need for servicing; and 5. No circuit adjustments needed once installed.

The magnetic amplifier answers these requirements and, in addition, is ready to go at the flip of a switch, has no moving parts, and needs only a few simple adjustments on installation. These qualities make the device superior, in a large number of applications, to other amplifiers, he said. As a power amplifier, it has been applied in: control of tandem steel-rolling mills; tension regulators and reel drives; control of ignitron rectifiers; voltage regulation for aircraft and synchronous machines; paper mill and lumber carriage drives, and so forth.

H. M. Ogle, General Electric Company, discussed the amplistat, or self-saturating type of magnetic amplifier. Power is consumed in the input winding, as all magnetic devices require ampere turns for operation; however magnetic circuits are often easier to design and have inherent galvanic isolation.

The factor of power separates the device into two types, the signal-power, and the output-power amplifier. The former has as variables gain, stability, linearity and speed of response, only one of which may be optimized. Power gain is the most fundamental, current gain the most useful variable. Circuit techniques for the signal-power type include feedback, push-pull operation, and multistage operation. In the output-power type, sufficient power, efficiency, minimum current, bias, and feedback are the criteria for optimum performance. In the discussion, Richard Spencer, Massachusetts Institute of Technology, demonstrated a junction transistor–magnetic amplifier device, which provides phase control similar to that of a thyratron.

The use of magnetic amplifiers in digital computers was described by D. A. Buck, Massachusetts Institute of Technology. Mr. Buck distinguished between two types, the saturable inductor and the saturable transformer, the use of one or the other being governed by the power-supply and load impedances.

Two circuits were shown, an in-line and a configuration circuit, using toroidal-core amplifiers and germanium-diode rectifiers. Both were based on the binary number system. Thirty-two channels can be provided in a configuration circuit of a size smaller than that using four miniature electron tubes, which would provide only eight channels, and would need much greater auxiliary power to operate.

The main limitation in the use of magnetic amplifiers in computers is the limit of speed; as the megacycle region is approached, core heating becomes prohibitive, and the rectifier does not respond fast enough. Ferrite cores, possessing very high resistivity, have reduced the losses; however, both eddy current and hysteresis loss increase with frequency in such cores (as contrasted with metallic-ribbon cores, where only eddy currents increase).

If the rectifier problem can be solved, the use of magnetic amplifiers in computers should become competitive with electron tubes, Dr. Buck concluded.

Two District papers were presented at the session at which power system communications was considered, and over which A. L. Davis presided. The first part of the paper, "Automatic Load-Frequency Control Via Power-Line Carrier on the New England Electric System," was read by R. E. Minkwitz and the second part by L. G. Eaton, both of the New England Power Service Company. The first part of the paper dealt with the load area of the company—all the New England states except Maine—and the means whereby the automatic control equipment maintains a uniform load on the regulating stations resulting in a close schedule of power interchange on the tie lines. Mr. Eaton's part of the paper described the push-to-talk party-line type of telephone system used and the frequency distribution for the telemetering and load-control channels.

The second paper of the session, "Communications on the Central Maine Power Company System," was by Basil Payne and A. H. Rogers, Mepsco Services, Inc. This paper described the telephone, supervisory control, carrier-current equipment, and mobile radio facilities used in the Maine system.

Four District papers were presented at the session dealing with productive maintenance over which G. J. Delehanty presided. H. F. McCullough, General Electric Company, in his paper, "The Key to Productive Maintenance," traced the rate of this country's population growth for the past 50 years, in the fall of 1952 there being a record-high population of 157,000,000 people. An estimate by the Bureau of Census is that by 1960 this figure will rise to 180,000,000. This population increase will mean a greater demand for all sorts of products and that the yearly output per employee must be increased 16 per cent to meet this demand. He showed that from 1899 to 1949, this country's workers have increased from 5 to 12.3 millions, the average work week has decreased from 60 to 40 hours, and the kilowatt-hours used annually by each worker has increased from 300 to 13,000. An estimate for 1959 was given: the workers will increase to 13.3 million and the work week will be shortened to 38 hours; the estimated electric power demand will be 20,000 kilowatt-hours per worker per year. Our economic security

Left to right: General Chairman F. B. Haeussler, W. C. White, A. C. Monteith, and W. S. Hill, Vice-Chairman of the General Advisory Committee, look over the banquet menu

depends on productivity. The more complex machines in use today must be maintained constantly to prevent breakdowns and consequent monetary loss to fulfill the demands of the future.

N. L. Danforth, St. Regis Paper Company, presented "Preventive Maintenance in a Paper Mill." He described the procedure of inspecting new motors and their maintenance; how lubricants are cared for before using, how the system of preventive maintenance for all electric equipment is recorded, and how these records have proved an economy.

"Maintenance Including Engineering in a Rubber Plant" was given by C. E. Ross, Hood Rubber Company. The author outlined the maintenance program in the company's trade shops, truck repairs, elevators, public-address system, and sanitation, as well as the maintenance of the electric power equipment used throughout the plant.

The final paper of the session, "Modern Elevator Maintenance," was given by L. K. Snowdon, Westinghouse Electric Corporation, who described and analyzed his company's available elevator service which is divided into general repair, maintenance, and modernization.

High-voltage transmission was discussed at a session at which H. R. Tomlinson presided.

L. E. Saline, General Electric Company, advocated the use of voltages above 230 kv for power transmission, making use of the old 138-kv and 69-kv lines for subtransmission. Dr. Saline said the trend is to the backbone type of system, larger-size conductors, heavier loadings, and compensation for transient stability problems.

The problems encountered in constructing electric power crossings over water were recounted by H. N. Furlong and L. O. Waite, Stone and Webster Engineering Corporation. The largest crossing, over Kootenay Lake, Canada, required a clear cable span of 10,656 feet, which is the longest such span in operation. (A 12,000-foot span is, however, under construction across the Messina Straits from Calabria to Sicily.) The possibility of introducing economies by use of existing utilities, such as railroad bridges, was emphasized, and the use of 3-legged towers advocated where settlement might occur.

A. A. Johnson, Westinghouse Electric Corporation, warned engineers that, as the use of electric power has been increasing exponentially, 175,000,000 kw should be expected by 1965; therefore, planning in advance for such capacity is vital. General rules for such planning are: prepare an ideal, long-range system plan; make use of existing equipment as much as possible; decide how existing facilities may be fitted into the ideal plan; make each change or addition so that it fits into the ideal plan; and modify the ideal plan to match changing load requirements.

A Student paper session was held on Friday morning.

The North Eastern District Prize Paper Competition was won by Theron Usher, Jr., Yale University, who presented a paper on an original method to determine multiple time constants experimentally. Second prize winners were D. R. Collins and A. E. Franz, Cornell University, who described their method of positional-feedback control, using a phasitron. The third place award went to L. R. Doyen, Northeastern University, for a review of the application of Chladni patterns to the vibration analysis of turbine wheels and buckets. The judges were Professor J. L. Warner, Tufts College; G. R. Blake, Westinghouse Electric Corporation; and Professor C. L. Dawes, Harvard University. The chairman of the Student paper session was Professor R. G. Porter, Northeastern University; Chairman, District Committee on Student Activities. A luncheon of the chairmen, Student counselors, and Student finalists was held after the meeting.

Participants in the Northern Textile Conference, held during the North Eastern District Meeting, were, left to right: R. A. Hudson, Saco-Lowell Shops; S. Cowan, Chairman, AIEE Textile Subcommittee; C. F. Hedlund, Associated Factory Mutual Insurance Companies; R. J. Demartini, F. C. Huyck and Sons; R. Browning, Booz, Allen and Hamilton; L. A. Runton, Alexander Smith, Inc.; V. F. Sepavich, Crompton and Knowles Loom Works; G. W. Knapp, General Electric Company

Industrial process control was the subject of the last session of the meeting. M. A. Princi, chairman, said in his introductory remarks that this was the first such session held at a District meeting. He stated that industrial control tended to lump other sessions together, because of the use by the industrial engineer of ideas and techniques from many branches of engineering.

The country's total investment in instrumentation was estimated by J. R. Ghublikian, Stone and Webster Engineering Corporation, to be 1.3 billion dollars, an increase of twice that prevailing just after the last war. Now, the cost of instrumentation is from 5 to 10 per cent of total plant investment. This increase has been characterized by an accelerated use of electric instruments, at the expense of the pneumatic types.

Mr. Ghublikian said that the more common types of control included temperature, pH, and conductivity measuring apparatus. He then showed how such controls are applied in the chemical process industry.

Dr. H. M. Paynter, Massachusetts Institute of Technology, demonstrated three practical methods to compute the response of closed-loop systems. The first was graphical analysis by the slope-line method of trapezoidal integration, which will solve any differential equation of any order approximately; the approximation being limited only by the thinness of the template used to draw the slope lines.

The second method was numerical, depending on discrete, linear operations, which change all differential equations into algebraic ones.

A third method, using analogue computer elements, was advocated by Dr. Paynter where continuous alteration of the variable is needed, and where cost is not a pressing factor (although he predicted that the day of the 500-dollar computer is not far off). A loop of computer elements were set up directly from a block diagram in a matter of a few minutes.

Dr. D. P. Campbell, Massachusetts Institute of Technology, presented a quick-change method whereby the frequency response and phase-shift character of an entire process loop could be determined. He advocated a change of quality-control measurement from the blendor stage back to the plant stage, which would eliminate the dead time between them, and thereby enable stability to be more easily achieved.

NORTHERN TEXTILE CONFERENCE

Two papers were presented at each of the two sessions of the conference over which V. F. Sepavich, Compton and Knowles Loom Works, presided.

G. W. Knapp, General Electric Company, read the first paper, "Electric Equipment Built Into Textile Machinery." After discussing the problems involved and the advantages of incorporating electric equipment into textile machinery by its manufacturer, the author gave as examples a comber, a cotton card drive, and a heat setting dryer for synthetic fiber fabrics.

"Engineering Safety Into Electric Equipment" was presented by C. F. Hedlund, Associated Factory Mutual Insurance Companies. Statistics covering 1940 to 1949 were given concerning the number of fires and property damage in cotton mills together with data showing the various causes of fires in each process and the number in percentages caused by different classes of electric equipment. The author presented a table classifying the fire hazard of various fibers and processes, which depends on the amount of lint produced in the processing.

R. J. Demartini, F. C. Huyck and Sons, was toastmaster at the Textile Conference luncheon and introduced Robert Browning of Booz, Allen, and Hamilton, whose subject was "Can the Textile Industry Afford Engineers?". In tracing the historical aspects of the textile industry, the speaker brought out

that during the 18th century the spinning and weaving processes were mechanized, but the industry did not continue its technical progress to any great extent—in fact, few fundamental technical changes have occurred in the past 50 years.

The first important indication of a desire by the textile companies to recover a modern engineering position is found in organizational changes within individual companies. Recently a committee submitted a report which recommended a 16-point program which would revitalize the textile industry in New England and three of the points concerned engineers. These points were adjusting work loads, increasing productivity, and reducing power and fuel differentials.

In order to sell management progressive ideas, the engineer must give as much thought to this selling job as he does to the engineering ideas themselves.

The new synthetic fibers have brought new ideas into the textile industry with their new blending and spinning processes, new dyeing and finishing methods, and new or modified weaving and other cloth-making processes which have come into being. All these involve new or modified equipment and operations and these require technical advice—an opportunity for the engineer.

There are other areas which challenge the industrial engineer supported by sound product engineering. The individual textile company may not be able to afford an engineer, but the equipment and material producers' technical staffs are a source of technical knowledge and should not be overlooked. Another source of engineering help is to be found in the independent research institutions and in the research departments of the colleges.

The speaker concluded his remarks with a plea to his listeners that they do everything in their power to persuade the textile industry that it must make greater and more effective use of engineering talent.

The first of the two papers of the afternoon session was "An Integrally Engineered Machine Is Economically Desirable" by R. A. Hudson, Saco-Lowell Shops. He traced the history of textile machinery manufacture for the past 125 years and the gradual incorporation of various mechanical and electrical components into the original design. As an example he explained how a "vacuum cleaner" attachment on a spinning frame was a time-saver in the event of broken ends. The incorporation of this device on existing machines involved many problems but customers demanded it. Now it is built into new model frames as an integral part of the unit. The same sort of integration took place in a lap winder in which a mechanical drive, a mechanical safety device, and a mechanical stop motion were redesigned around an electric motor drive so that all the drives were electric.

In some instances textile mills buy motors and other items from sources other than the manufacturer of the machinery and assemble them into the machine in their own shops. In the event of anything going wrong, the maker of the original machine is held responsible and he must find the trouble. It is logical that the machinery manufacturer should incorporate all the latest devices into his machine and so give the mills an integrated product.

The final paper of the session, "The Value of the Engineer in the Textile Mill," was presented by L. A. Runton, Alexander Smith, Inc. He showed how an engineer can safeguard the mill's profit and loss account by projecting ahead the costs which accrue in a plant in view of the orders taken and the utilization of the equipment. The average cost per kilowatt-hour of power generated by a textile mill is 2.6 cents per kilowatt. In many instances this could be bought on the outside for 1.65 cents, which would mean a substantial saving in the course of a year.

Mr. Runton also gave an analysis of how different machines could be engineered so that their output could be materially increased; this also would mean a saving. The engineer also can effect savings by making a motion study of the most competent workers and then showing others how they can increase their efficiency, and incidentally their pay. In short, the engineer can be a great asset to a mill by applying engineering principles to its problems.

COMMITTEES

Members of the General Advisory Committee for the North Eastern District Meeting were: F. B. Hacussler, General Chairman; C. J. Crowdes, Secretary; L. F. Cleveland, Historian; W. S. Hill, Vice-Chairman; C. L. Devoe, Treasurer; C. A. Powel, Counselor; C. T. Abbott, C. W. Maloney, S. M. Osthagen, H. P. Turner, E. W. Boehne, W. F. Potter, L. J. Weed.

Chairmen of the other committees responsible for arranging the meeting were: E. W. Dillard, Budget and Finance; F. D. Snyder, Technical Program; A. L. O'Banion, Registration; J. C. Hitt, Hotel Arrangements; L. T. Jester, Publicity; W. A. Carlson, 50th Anniversary Banquet and Smoker; J. F. Archibald, Inspection Trips and Transportation; Mrs. L. J. Weed, Mrs. G. J. Crowdes, Ladies' Entertainment; F. S. Bacon, Jr., Hospitality; J. J. Loustaunau, Social Hour; R. G. Porter, Students; S. Cowan, AIEE Textile Subcommittee.

Recent District Meeting Papers Available Upon Request to Authors

A number of authors who presented District papers at recent AIEE District meetings have announced their willingness to supply copies of these papers upon request. (District papers are not scheduled for publication in AIEE *Transactions*.) A list of currently available papers follows. Readers desiring copies should write directly to the respective authors, at the addresses given.

SOUTHERN DISTRICT MEETING

Measuring and Recording Small Voltage Variations Produced by Variable Loads
Rhea W. Baker, Chief Distribution Engineer, Georgia Power Company, P. O. Box 1719, Atlanta 1, Ga.

Electric Power, A Creative Force
Professor C. G. Brennecke, North Carolina State College, Raleigh, N. C.

Operating Experience With Connectors for Aluminum Conductors
(C. E. Bryan, J. H. Exum)
Charles E. Bryan, Chief Engineer, Jackson Electric Department, 119 East College Street, Jackson, Tenn.

Radiotelephone From Wilmington to Shallotte
William C. Burnett, Southern Bell Telephone and Telegraph Company, Box 240, Charlotte 1, N. C.

Neutral Grounding of Industrial Power Systems
Lewis J. Carpenter, General Electric Company, Schenectady, N. Y.

The Influence of Shunt Capacitance Variation Upon the Performance of the Self-Saturating Magnetic Amplifier
Yun Chang, Graduate Training Section, Allis-Chalmers Manufacturing Company, South 70th Street and West Greenfield Avenue, West Allis, Wis.

A Discussion on Methods of Measuring Space Charge
William B. Dodson, American Air Filter Company, 215 Central Avenue, Louisville, Ky.

Design Criteria for Tube Aging and Tube Testing Facilities at Oak Ridge National Laboratory
George A. Holt, Oak Ridge National Laboratory, P. O. Box P, Building 3500, Oak Ridge, Tenn.

Rigorous Calculation of the Capacitance and Characteristic Impedance of Coaxial Transmission Lines Composed of Rectangular Tubular Conductors
(T. J. Higgins, S. Hori)
S. Hori, Armour Research Foundation, Technology Center, Chicago 16, Ill.

Fan Cooling of Transformers and Their Economics
(C. R. Jager, W. L. Windham)
Charles R. Jager, Alabama Power Company, 600 North 18th Street, Birmingham 3, Ala.

Education and Training for Living
Claudius Lee, Virginia Polytechnic Institute, Box 157, Blacksburg, Va.

A Simplified Method of Field Testing Network Protectors
J. H. Miller, Jr., Alabama Power Company, 68 St. Francis Street, Mobile, Ala.

Technical Aspects of Electric Equipment Applications in Coal Preparation Plants
W. R. Morton, General Electric Company, 1 River Road, Schenectady, N. Y.

Restraining the Repulsive Forces in Large Duplex Current-Limiting Reactors
L. E. Sauer, Westinghouse Electric Corporation, 469 Sharpsville Avenue, Sharon, Pa.

Shape-Correction Factors for Calculating Short-Circuit Forces of Busses Composed of Double-Channel Conductors
(C. M. Siegel, T. J. Higgins)
Clifford M. Siegel, Department of Electrical Engineering, University of Virginia, Charlottesville, Va.

The Determination of Rotor Inductance and Resistance for a Drag-Cup Servomotor
Dr. William A. Stein, United States Naval Postgraduate School, Electrical Engineering Department, Monterey, Calif.

A Variable-Frequency Drive for Synthetic-Fiber-Spinning Machines
Harry L. Stiltz, 749 Intermont Circle, Hixson, Tenn.

Progress in Current Transformer Design
(F. J. Vogel, D. R. Laib)
F. J. Vogel, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Design of a Dispatching Office
(W. J. Wortman, H. E. Redding)
W. J. Wortman, Duke Power Company, Charlotte, N. C.

Cathodic Control of Corrosion
William T. Zumwalt, Tennessee Valley Authority, 316 Ludlow Avenue, Knoxville, Tenn.

NORTH EASTERN DISTRICT MEETING

Magnetic Amplifiers in Digital Computers
Dudley A. Buck, Massachusetts Institute of Technology Digital Computer Laboratory, 68 Albany Street, Cambridge, Mass.

Automatic Load-Frequency Control Via Power-Line Carrier on the New England Electric System
(L. G. Eaton, R. E. Minkwitz)
L. G. Eaton, New England Power Service Company, 441 Stuart Street, Boston 16, Mass.

A Practical Method for Plotting Electrostatic Field Distribution and Equipotential Lines
(G. E. Jansson, William Harper)
W. E. Harper, Allis-Chalmers Manufacturing Company, 1344 Hyde Park Avenue, Hyde Park 36, Mass.

Engineering Safety Into Electric Equipment
C. F. Hedlund, Factory Mutual Engineering Division, 184 High Street, Boston, Mass.

Equations for the Inductance and Short-Circuit Forces of 3-Phase Busses Comprised of 120-Degree Angles
Professor Thomas J. Higgins, Department of Electrical Engineering, Engineering Building, University of Wisconsin, Madison, Wis.

System Planning for Load Growth
A. A. Johnson, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Electric Equipment Built Into Textile Machinery
G. W. Knapp, General Electric Company, Schenectady, N. Y.

Comparison of Microwave Versus Carrier Channels for Protective Relaying
H. W. Lensner, Westinghouse Electric Corporation, 95 Orange Street, Newark 1, N. J.

Magnetic Amplifier Circuit Techniques
H. Malcolm Ogle, General Electric Company, Building Number 37, 1 River Road, Schenectady 1, N. Y.

The Value of the Engineer in the Textile Mill
Leslie A. Runton, Alexander Smith, Inc., 525 North Broadway, White Plains, N. Y.

Technical and Economic Aspects of High-Voltage Transmission
L. E. Saline, General Electric Company, Schenectady, N. Y.

Bus Voltage Regulation
D. R. Samson, General Electric Company, 1 River Road, Schenectady, N. Y.

A Simple Relay Scheme for Unit Generator-Transformer Station
George Steeb, Niagara-Mohawk Power Corporation, Electric Building, Buffalo 3, N. Y.

Unusual Problems in Construction of Electric Power Crossings
(H. W. Furlong, L. O. Waite)
L. O. Waite, Stone and Webster Engineering Corporation, 49 Federal Street, Boston 7, Mass.

APPLIANCE TECHNICAL CONFERENCE

Copies of all papers presented in the sessions of the Appliance Technical Conference can be obtained from J. H. T. Miller, Jr., Cleveland Electric Illuminating Company, 75 Public Square, Cleveland 1, Ohio. Titles and authors of these papers appear in the April issue of *Electrical Engineering*, page 358, with the program for the AIEE Southern District Meeting.

Officers Announced for New Monroe Subsection

H. B. Balfour, division engineer for the Louisiana Power and Light Company, has been elected Chairman of the newly organized Monroe Subsection of the AIEE Shreveport (La.) Section.

D. E. Blivins, Brown Paper Mill, has been elected Secretary-Treasurer and H. M. Rhodes, Consulting Engineer, has been appointed Program and Publicity Chairman. The new Members Committee consists of Percy Lubke (Chairman), Ford, Bacon and Davis Construction Company; D. F. Burkhalter, Collins Electric Company; and R. B. Bailey, Louisiana Power and Light Company.

The industrial growth of Monroe, La., over the past decade has enabled the formation of this Subsection in the Monroe–West Monroe area. The Subsection was organized through the efforts of a group headed by Chairman W. C. Morris, Jr., of the Shreveport Section. Others were Past Chairman Carl Pons; S. M. Sharp of the AIEE Sections Committee; A. M. Randolph, Publicity Committee Chairman; and Past Chairman L. T. Williams.

Fortescue Fellowship Awards Announced for 1953–54

The Charles LeGeyt Fortescue Fellowship Committee of the Institute has awarded fellowships for graduate study in electrical engineering during the academic year 1953–54 to Richard C. Heyser and John M. Tomlinson.

Mr. Heyser, who is from Phoenix, Ariz., is an honor student at the University of Arizona where he will receive his bachelor of science degree in electrical engineering this month. A Student member of the AIEE and an associate member of the Institute of Radio Engineers (IRE), he was elected to Tau Beta Pi, Sigma Pi Sigma, and Pi Mu Epsilon, honor societies. He has presented two papers to the AIEE-IRE Student Branch at Arizona and another paper won first prize in the Pi Mu Epsilon Essay Contest in 1952.

Mr. Heyser will enter the California Institute of Technology this fall to take graduate work in the computer field.

Mr. Tomlinson is working toward his masters degree at Pennsylvania State College under a graduate assistantship at the present time. The fellowship will enable him to

Milwaukee Section Officers

Activities of the AIEE Milwaukee Section are handled by the above engineers: Seated (left to right): C. P. Feldhausen, Junior Past and Finance Chairman; E. J. Limpel, Section Chairman; J. A. Deubel, Section Secretary-Treasurer; F. J. Van Zeeland, Past Section and Nominating Committee Chairman. Standing (left to right): B. G. Wheeler, Transfers Chairman; D. R. Kanitz, Membership Chairman; H. D. Langley, Electronics Vice-Chairman; J. F. Frank, Power Application and Control Chairman; E. R. Lamb, Electronics Chairman; G. Hutchinson, Director; L. C. Wasson, Basic Science Chairman; R. J. Ungrodt, Director and Student Activities Chairman; J. M. Fleissner, Program Chairman; and Alex Paalu, Education Chairman. Not present were: Directors E. A. Dickinson, R. C. Ball, V. J. Egan, N. C. Storck; E. H. Fredrick, Senior Past Chairman; W. J. Cherones, Historical Chairman; E. L. Nicolson, Professional Development Chairman; N. W. Hoffman, Co-ordinating Chairman; W. Kremmel, Electric Machinery Chairman; G. L. Atkinson, Transmission and Distribution Chairman; and H. C. Brem, Publicity Chairman. The Milwaukee Section has a membership of nearly 1,000 which includes two Subsections, the Fox River Valley Subsection, with Chairman D. C. Christinson, and the Racine-Kenosha Subsection with Chairman R. Garrett

complete his masters degree and to start work on his doctorate during the coming academic year.

While at Pennsylvania State, Mr. Tomlinson has been honored by election to Eta Kappa Nu, Tau Beta Pi, Sigma Tau, and Phi Eta Sigma. He is a member of the AIEE-IRE Joint Student Branch, serving as chairman in 1951–52. In 1952 he also served as chairman of the District 2 Student Prize Paper competition. He is presently devoting part of his time to a computer research project at Pennsylvania State College, and has gained additional experience by working during recent summers with Bethlehem Steel Corporation, Bell Telephone Laboratories, and Westinghouse Research Laboratories. His home town is Montoursville, Pa.

The Fortescue Fellowships were established through a trust fund set up by the Westinghouse Electric Corporation in recognition of Mr. Fortescue's valuable contributions to the electric power industry.

Engineers Joint Council Reports Activities for 1952

The Engineers Joint Council (EJC) Annual Report for 1952, recently issued, summarizes the year's activities, presents the constitution as of December 7, 1952, and includes a list of the standing committees for 1953.

A highlight of the year for EJC was the decision to broaden the scope of the Council and include in its membership all eligible engineering societies who wish to join. In addition to the AIEE, present member societies are the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers. However, several of the additional societies have indicated their willingness to join, and it is hoped that by expanding the membership of EJC, and by changing its constitution to make it more truly representative of the active work in the member societies, a step toward greater unity of the profession will have been achieved.

One of the most active projects of EJC during the year was the Engineering Manpower Commission which has become recognized as the authority on engineering manpower.

With private financial support, the Commission has been largely responsible for a sharp increase in the number of freshmen enrolled in engineering colleges, and for suggesting changes in laws and procedures for various national defence agencies.

Another important activity was the setting up of an Atomic Energy Panel, for 1953, which will prepare, subject to approval by the Council, ideas for presentation to the Joint Committee on Atomic Energy concerning changes in the Atomic Energy Act of 1946, which may be needed to encourage ventures in the field of atomic energy by privately owned industries. W. L. Cisler has been named chairman of the panel, and B. R. Prentice is the AIEE representative.

Anyone specifically interested in further details of the EJC report may obtain copies from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

Women's Auxiliary Sets Up Scholarship

At the closing meeting of the year, Mrs. H. R. Paxson, Chairman of the Women's Auxiliary to the AIEE Philadelphia Section, presents to Dr. C. C. Chambers, dean of the Moore School of Electrical Engineering, University of Pennsylvania, a check for a new scholarship fund while Philadelphia Section Chairman L. R. Gaty looks on. The scholarship will be awarded to an electrical engineering student in the Philadelphia area and will be available in September. Following the presentation, the following officers were elected for the coming year: Mrs. W. F. Denkhaus, Chairman; Mrs. C. R. Pearce, Vice-Chairman; Mrs. G. B. Schleicher, Recording Secretary; Mrs. W. F. Henn, Corresponding Secretary; and Mrs. L. R. Gaty, Treasurer

District 2 Student Branch Holds Prize Paper Contest

The District 2 (Middle Eastern) Branch Prize Paper Contest was held at Bucknell University, Lewisburg, Pa., April 24–25, 1953.

First place in the contest went to L. A. DiPaolo, A. J. Kane, and C. A. Quinn, all of Villanova College, for their paper entitled "The Linear Variable Differential Transformer." The paper was presented by Mr. DiPaolo. Second place went to D. M. Barger, Johns Hopkins University, who wrote and presented a paper entitled, "An Electronic Stimulator for Use on the Human Eye." Third place was won by a paper, "Memory Systems in High-Speed Computing Machines," written and presented by E. G. Halline, Bucknell University.

The first-prize certificates will be presented at the General Session of the Summer General Meeting in Atlantic City, N. J.

Columbus Section Awarded Plaque

E. Bischoff (left), president of the Franklin County chapter of the Ohio Society of Professional Engineers, presents a plaque to F. H. Knapp, Chairman, AIEE Columbus (Ohio) Section, for the best display set up in windows and lobbies of downtown buildings in Columbus to depict progress in engineering in conjunction with "National Engineers Week"

AIEE Lynn Section Elects New Officers

At a recent meeting of the AIEE Lynn (Mass.) Section, E. K. Rohr of the General Electric Company was elected Chairman to serve for the coming year. The past chairman is T. C. Sargent, Sylvania Electric Company.

Other newly elected officers are: J. R. Macintyre, General Electric Company, as Vice-Chairman; S. W. Stawicki, Champion Lamp Company, as Secretary-Treasurer; and F. O. MacFee, Jr., Sylvania Electric Company, as Assistant Secretary-Treasurer.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Wire Communications Systems (*P. G. Edwards, Chairman; H. R. Huntley, Vice-Chairman; L. R. Montfort, Secretary*). The committee sponsored a technical session at the Winter General Meeting in which four papers were given dealing with the new long-haul coaxial cable system. These papers were concerned with the application of the system amplifiers, equalization regulation, and television terminals.

The committee meeting also was held coincidental with the Winter General Meeting, and plans were made to sponsor technical sessions at the forthcoming Summer and Pacific General Meetings.

Industry Division

Committee on Mining and Metal Industry (*A. C. Muir, Chairman; W. R. Harris, Vice-Chairman*). The Committee on Mining and Metal Industry during the past year has reorganized its committee structure to expand its activities to include: promotion of technical papers; organization of round-table discussions and conferences; preparation of committee progress reports or special publications; promotion and organization of special technical conferences; sponsorship of work or studies leading to standards.

The committee considers the sponsorship of work or studies leading to standards to be one of the most important activities for AIEE technical committees. The planning group, selected from the committee membership, prepared guides to be used by the chairman of each of the three subcommittees in making assignments to the members of his subcommittee.

General Applications Division

Committee on Domestic and Commercial Applications (*T. H. Cline, Chairman; T. C. Johnson, Vice-Chairman; J. H. T. Miller, Secretary*). The Subcommittee on Space Heating and Heat Pumps for the East Coast sponsored a technical program at the 1953 Winter General Meeting, at which time a progress report was made on the storage of heat as a means of reducing the demand factor and the load on the transmission and distribution system. Other papers were presented showing various phases of the heat pump problem as it related to the distribution system and to its operation and function in the home.

The Subcommittee on Farm Electrification is now actively planning a conference for approximately October on the many applications and problems involved in the use of electricity on the farm. It is believed there is much interest in the application of electricity to the farm and that this conference will develop into a very desirable activity for the committee.

Denver Section Presentation

At the March meeting of the AIEE Denver (Colo.) Section, Chairman R. B. Hubbard presented the Past Chairman Certificate to E. R. Jones. Left to right are: H. F. Gidlund, Vice-Chairman; Mr. Hubbard; Mr. Jones; and A. E. Paige, Secretary-Treasurer

Committee on Marine Transportation (*J. B. Feder, Chairman; W. E. Jacobsen, Vice-Chairman; W. N. Zippler, Secretary*). Since the last meeting, the several subcommittees have reviewed clarifications, changes, and additions to Standard Number *45*.

The Subcommittee on International Electrotechnical Commission (IEC) Standards has been reviewing the first comprehensive draft of a proposed "Code on Electrical Installations on Ships" prepared by Technical Committee *18* of the IEC. Comments thereon are being compiled for possible presentation to the Commission.

Special subcommittees have been consulting with manufacturers of shipboard equipment on standardization of special marine requirements for the equipment.

Power Division

Committee on Insulated Conductors (*C. T. Hatcher, Chairman; R. J. Wiseman, Vice-Chairman; M. H. McGrath, Secretary*). During the current year the past policy of holding two meetings of the committee was continued. A 2-day session was held in New York, N. Y., on November 20 and 21, 1952, and another 2-day session in Pittsburgh, Pa., on April 20 and 21, 1953. The 2-day sessions have been found to be very desirable as they provide sufficient time for the subcommittees to hold their individual meetings and then meet together for over-all reports and discussions.

The sessions at the Fall General Meeting in New Orleans, La., on insulated aluminum were very successful and, as a result of the interest shown in the conference papers which were presented, approval has been obtained for publishing them in a special AIEE publication.

Committee on Carrier Current (*C. W. Boadway, Chairman; S. C. Leyland, Vice-Chairman (East); R. H. Miller, Vice-Chairman (West); B. W. Storer, Secretary*). Considerable thought and effort have been given to the Symposium on Carrier Current and Microwave to be sponsored by the Committee on Carrier Current during the 1953 Pacific General Meeting in Vancouver, Canada. Tentatively, the date has been set for all day Wednesday, September 2.

During the morning a committee report entitled "Application Guide for Carrier Current" will be presented as a basis for discussion on the subject of carrier current. Similarly, in the afternoon, the discussion on microwave will be introduced by the presentation of a committee report on "Installation and Operating Experience With Microwave for Power System Operation." Ample time will be available following each report for a question and answer period, and each session will be presided over by a chairman and group of advisors qualified to give expert advice on the problems presented.

It is hoped that this type of conference will stimulate interest in the use of these important services for power system operation, and that those engaged in all phases of the power field will avail themselves of the opportunity to become more fully acquainted with present techniques and applications and the latest in carrier-current and microwave developments.

Science and Electronics Division

Committee on Nucleonics (*G. W. Dunlap; Chairman; W. E. Barbour, Jr., Vice-Chairman; H. W. Bibber, Secretary*). Few other committees of the AIEE operate under the security difficulties which face the Committee on Nucleonics. It is anxious to co-operate with all government agencies in maintaining proper security restrictions, but attempts to make available to interested AIEE members details of nuclear developments related to electrical engineering as rapidly as they are declassified.

Attendance at sessions it has sponsored, as well as correspondence, has indicated the major interests of AIEE members now as: (1) reactor operation and control, (2) nucleonic instruments, and (3) radioactive tracers in studies of materials used in equipment. Much of the subject matter in item 1 is related to feedback control systems, and in item 2 is related to instruments and measurements, so that joint activities with these as well as many other committees in the AIEE have represented a large part of its activities. Examples of such activities include participation with the Committee on Electrical

St. Lawrence International Subsection

On April 15, 1953, the St. Lawrence International Subsection of the AIEE Syracuse (N. Y.) Section met in Potsdam, N. Y. Seated at the main table are shown, left to right, Past Chairman N. O. Ross and Mrs. Ross; Subsection Chairman L. F. Pries and Mrs. Pries; M. S. Paige, speaker for the evening; J. J. Hays, who introduced the speaker; Past Chairman P. F. Mengel and Mrs. Mengel; and Dr. A. R. Powers, who played a large part in the founding of the Subsection

Techniques in Medicine and Biology, in holding a conference in New York in November each year on "Electronic Instrumentation and Nucleonics in Medicine"; talks by leaders in the field at the general session of the 1953 North Eastern District Meeting on atomic power, and on nuclear research in retrospect and in prospect; and a joint session with the Committee on Power Generation at the Summer General Meeting in June 1953 on the subject of atomic power development.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, January 22, 1953

Joseph W. Allen (M '41), senior electrical engineer, Eclipse Pioneer Division, Bendix Aviation Corporation, Teterboro, N. J., has been transferred to the grade of Fellow in the AIEE "for pioneering and outstanding achievement in the development of electric systems and equipment for aircraft." Mr. Allen was born in Carbondale, Pa., March 12, 1893, and graduated from Bucknell University in 1915 with a bachelor of science degree in electrical engineering. Upon completing the test course at the General Electric Company, Schenectady, N. Y., he was assigned to the synchronous converter department. While there he enlisted in the Signal Corps during World War I, and after a flight training course received his commission and qualified as a pilot. After World War I he accepted a position at McCook Field (now Air Material Center), Dayton, Ohio, in connection with the development of air-borne electric equipment. This work included development, test, and approval of generators, generator controls, starters, storage batteries, ignition and power cable, switches, interior and exterior lighting. The work stressed reduction of weight and size. By 1926 Mr. Allen had been placed in charge of all work of the electrical branch. In 1928 he accepted a position with Eclipse, a division of Bendix Aviation, and was advanced to chief electrical engineer prior to 1940. In 1942 he joined the Bureau of Aeronautics where he was placed in charge of development, application, and approval of rotating machinery for use in Naval aircraft. He returned to Eclipse-Pioneer Division of Bendix as senior engineer in charge of development of aircraft electrical accessories, which includes a-c and d-c generators, motor-generator units, motors, generators, control units, and fault protective systems. Mr. Allen has received over 40 patents and has evidenced originality also in the design of electric machines and equipment for aircraft where high densities of current in both brushes and copper as well as iron were proved to be practicable beyond the accepted recommended ranges because the heat rejection in a small unit was possible and advisable in reducing size and weight. He conceived, projected, and built the first a-c system installed in an aircraft as such. During the entire war period, 1941–46, generators for aircraft were procured and applied without formal specifications based on his experience and judgment with only laboratory tests as a guide. Mr. Allen has been continually and intimately concerned with and active in the engineering and development phase of electric power for aircraft since 1920. He is a member of the Institute of the Aeronautical Sciences and the Society of Automotive Engineers and has served on the AIEE Committees on Air Transportation (1944–53) and Standards (1946–53).

Andre G. Clavier (M'48), technical assistant to president, Federal Telecommunication Laboratories, Inc., Nutley, N. J., has been transferred to the grade of Fellow in the AIEE "for pioneer work in research, development, and engineering in communication in the microwave field." Mr. Clavier was born in Cambrai, France, February 15, 1894, and received an ingenieur diplomé de l'École Superieure d'Electricité in 1920 from the Sorbonne, Paris, France. From 1920 to 1925 he was department head, French Signal Corps Laboratories, Paris, where he worked on short-wave developments and the design of advanced military radio equipment. He was division head, Société Française Radioélectrique, Paris, from 1925 to 1927 working on design of short-wave transmitters of special types. In 1929 he joined Laboratoire Central de Telecommunications, an affiliate of International Telephone and Telegraph Company, Paris, as a division head. In 1930 he designed and supervised a microwave link on 1,700 megacycles over the English Channel. He did other work on microwave links in England and France and conducted propagation studies of fading on microwave links. He also conducted research on positive grid tubes and waveguide magnetrons. He became assistant research director at the laboratories in 1944. From 1942 to 1946 he also was a professor of electromagnetic field theory at École Superieure d'Electricité Malakoff, Seine, teaching a course for postgraduate students. He came to the United States in 1946, joining Federal Telecommunication Laboratories as assistant technical director. In 1949 he became technical assistant to the president, handling special technical and administrative assignments. Mr. Clavier is a member of the Société Française des Electriciens and the Société des Radioélectriciens, France, the Institution of Electrical Engineers, Great Britain, and a fellow of the Institute of Radio Engineers. He has served on the AIEE Committee on Special Communications Applications (1951–52).

Albert A. Nims (AM '11, M '28), electrical engineering department, Union College, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions to the electrical engineering profession in the theory and design of arc-welding equipments, armature windings of electric machines, and in electric network analysis. Also, outstanding contributions to engineering education." Mr. Nims was born in Montague, Mass., August 1, 1886, and graduated from Worcester Polytechnic Institute in 1908 with a bachelor of science degree in electrical engineering. He received the electrical engineering degree from the same institution in 1911. Mr. Nims was design engineer for the Crocker Wheeler Company, Ampere, N. J., from 1912 to 1919, specializing in d-c machines. He was engineer-in-charge of design and construction for the Siemund Wenzel Electric Welding Company, New York, N. Y., from 1919 to 1922, specializing in electric arc-welding equipment. In 1908 he began his teaching career as part-time assistant instructor at Worcester (Mass.) Polytechnic Institute; in 1917 he resumed his teaching of engineering as night school instructor at The Cooper Union, New York, N. Y. In 1918 he began, as an evening instructor, his long engineering-teaching career at Newark Technical School and Newark (N. J.) College of Engineering. In 1922 he left industry for full-time teaching at Newark College of Engineering. He was made chairman of the electrical engineering department, a post which he held until his retirement in 1952. Mr. Nims joined the staff of the department of electrical engineer-

Joseph W. Allen

Andre G. Clavier

Albert A. Nims

ing at Union College early in 1953. Mr. Nims has designed and developed one of the first single-operator arc-type welding generators with inherent regulation; he designed a new multiple-wave armature winding with the commutating characteristics of the simplex lap winding and the flux averaging characteristics of the simplex wave winding. He applied the Potier triangle techniques to the predetermination of the regulation characteristics of d-c machines of all types; he developed a general theoretical approach to the subject of armature windings, embodied in a monograph which was used as the text for a course in the subject, and he originated material in advanced network analysis concerned principally with resonant coupled circuits. Mr. Nims initiated pioneering groundwork in electrical engineering subjects which constitute the separate courses in networks, electronics, and electric circuit transients, and organized the electrical engineering curriculum along the lines of electric circuits, electronics, and electric machines. Mr. Nims is a member of the American Society for Engineering Education, Tau Beta Pi, and Sigma Xi.

Minot H. Pratt (M '34), division engineer, Niagara Mohawk Power Corporation, West Syracuse, N. Y., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions in the development of improved methods and equipment essential to the efficient operation of a major electric distribution system." Mr. Pratt was born July 4, 1903, in Providence, R. I., and graduated from the University of Pennsylvania in 1926 with a bachelor of science degree in mechanical engineering. Following his graduation he was selected by the United Gas Improvement Organization as a cadet engineer assigned to the Syracuse (N. Y.) Lighting Company as helper in the underground cable department. Subsequently he was placed in charge of a construction crew working on new cable manholes and duct lines. The next year he was made engineering assistant to the electrical distribution engineer. He prepared an original study based on field investigations and discussions with others on "Cedar versus Pine Poles for Distribution Lines." In October 1927 Mr. Pratt was made assistant distribution engineer with full charge and responsibility for supervision of all new line layout work of all voltages, load testing, radio interference, construction progress, and the distribution and transmission system maps and records. Mr. Pratt became assistant to the executive responsible for engineering, operation, and construction of electrical facilities in 1928. He investigated work methods which led to the development of a trailer-type tool box to replace the heavy trunk-type containers used by underground cable splicing crews and also studied and designed a sectional-type manhole form for building concrete manholes. He became engineer of the electric department in 1929 with sole responsibility to management for engineering, operation, construction, and maintenance of electrical properties. In 1931 he became assistant division engineer for the Central Division, Niagara Hudson Power Corporation, and in 1932 he was named division electrical engineer. His duties were the direct supervision of the electrical section's engineering and design work. During these years, Mr. Pratt was active in the use of high-impulse insulation designs for intermediate-voltage transmission lines and in the study of various lightning protective designs for such lines. In 1946 Mr. Pratt was made chief engineer for Central New York Power Corporation (a consolidation of former Niagara Hudson divisions) in full charge of the planning and design of the electric and gas facilities and systems; special studies and research relating to economics, depreciation, load flows; the establishment of construction standards for overhead and underground lines and substations, including gas transmission and distribution; the development of engineering property records; construction budgets; technical specifications for contracts, materials; and inspection and approval of all construction. In January 1950 the major operating companies of the Niagara Hudson System were consolidated into a single operating company, Niagara Mohawk Power Corporation, Mr. Pratt becoming division engineer. He is a member of Tau Beta Pi, Sigma Xi, and the National Society of Professional Engineers, and has served on the AIEE Committee on Transformers (1947–53).

George B. Scheer (AM '37, M '40), chief consulting electrical engineer, Kaiser Engineers Division, Henry J. Kaiser Company, Oakland, Calif., has been transferred to the grade of Fellow in the AIEE "for outstanding achievements, ingenuity, and broad engineering ability in designing power supply and electric equipment layout for aluminum reduction plants and steel mills, including a number of electrical applications new to the industry." Mr. Scheer was born in San Francisco, Calif., April 2, 1898, and graduated from the University of California in 1920 with a bachelor of science degree in electrical engineering. He then attended the Westinghouse Electric and Manufacturing Company's (now Westinghouse Electric Corporation) engineering school and in 1921 became a design engineer in that firm's East Pittsburgh, Pa., plant. From 1922 to 1936 Mr. Scheer was engaged in engineering and contracting work in San Francisco, being employed by several municipalities on proposed and actual municipal ownerships of electrical utilities. In 1936 he became a senior electrical engineer for the State of California on the designing of electrical facilities on the San Francisco–Oakland Bay Bridge. This work involved a double-track interurban railway system with overhead and third-rail power lines and an automatic signal control. He also was charged with the studies of electrolysis problems on the bridge. Upon completion of the bridge in 1939 he returned to the consulting profession and as a consultant for various Kaiser industries was responsible for the electrical work at Permanente Cement, the 11-mile conveyor at Shasta Dam, the carbothermic magnesium plant at Permanente, and the steel plant at Fontana. He was in charge of complete design of all electric power facilities for Permanente Metals Corporation's Magnesium Plant, Permanente, Calif. (approximately 60,000-kva main substation capacity) together with design of two associated plants at Natividad, Calif. (approximately 2,000-horsepower connected load) and Magnesium Seawater Plant, Moss Landing, Calif. From 1942 to 1944 he was in charge of design of complete electric power facilities for fully integrated iron and steel plant at Fontana, Calif., having an installed capacity of ap-

Minot H. Pratt

George B. Scheer

Kilburn M. Smith

Dimitri Trone

William W. Wishard

John C. Woods

proximately 40,000 kva. Facilities provided for were blast furnace, coke plant, boiler plant, plate mill, structural mill, merchant mill, and related auxiliaries. Mr. Scheer also was in charge of design for Shell Manufacturing Plant, Fontana and Denver, Colo., with a total capacity of approximately 40,000 horsepower. In 1946, when Kaiser Engineers was organized as an engineering company, he became their chief consulting electrical engineer and since that time, in addition to the over-all electrical responsibility, has had charge of the electrical development of the steel plant at Fontana, the electrical work in the aluminum reduction plants, and has been in charge of all phases of a 473,000-kw powerhouse for an aluminum plant at New Orleans, La. Mr. Scheer is a member of the Engineers Club of San Francisco, the Electrochemical Society, and the Association of Iron and Steel Engineers. He has served on the AIEE Committees on Electrochemical and Electrothermal Applications (1947–53) and Electronic Power Converters (1952–53).

Kilburn M. Smith (AM '25, M '33), system planning engineer, Engineering Department, Commonwealth Edison Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for contributions to the field of power system engineering, particularly in the pioneering of high-voltage transmission of bulk power in densely loaded areas." Mr. Smith was born in Hingham, Mass., May 18, 1902, and graduated from Massachusetts Institute of Technology in 1923 with a bachelor of science degree in electrical engineering. He entered the Engineering Department of Commonwealth Edison the same year. His first assignment was in the design of the 4,000-volt distribution system. When the low-voltage a-c network system of distribution was introduced in Chicago in 1933, Mr. Smith was placed in charge of planning the development of this system. In 1937 he was made a supervising planning engineer, and in 1943 he was appointed assistant system planning engineer. In 1949 he was named to his present position. In his capacity as planning engineer, Mr. Smith has had the major responsibility for the development and growth of the a-c network system in Chicago. Since the start of the system in 1936, the system supplying the downtown and immediately adjoining areas of the city has grown to a total of over 200,000 kva. Mr. Smith pioneered the use of 480-volt spot networks in large buildings, a move which has been quite successful in Chicago. He also has been active in the development of the transmission and general distribution system in the Chicago area. He has co-operated in the initiation of the use of 66,000 volts for subtransmission in the area. This system has been expanded to supply five substations with a total load of about 250,000 kva, with other similar installations authorized but not yet in service. Mr. Smith's responsibilities have included planning adequate electrical capacity of all system units from generating stations to circuit feeders, for system relay protection, and for the application of new engineering ideas to the system where economy of design or quality of service could be improved. He now has the major responsibility for all system planning activities for a system with a load of approximately 3,000,000 kw. Mr. Smith is a member of the Western Society of Engineers and has served on the AIEE Committee on Transmission and Distribution (1948–50).

Dimitri Trone (AM '24, M '30), chief engineer, General Electric S. A., Rio de Janeiro, Brazil, has been transferred to the grade of Fellow in the AIEE "for pioneering activities in electric power generation on the electrification of transportation system in foreign fields, particularly in Russia and Brazil." Mr. Trone was born in Riga, Latvia, September 14, 1901, and received his bachelor of science degree in electrical engineering from Union College in 1923 and his masters degree in 1924. After doing advanced work at Massachusetts Institute of Technology, Mr. Trone joined the General Electric Company in 1925. Upon completion of the company's test course he was assigned to the Large Power Transformer Design Department, Pittsfield, Mass., and the next year was transferred to the Central Station Engineering Department, Schenectady, N. Y. There he participated in work on selection and application of electric equipment for hydroelectric and steam-turbine electric power stations, step-up and step-down substations; short-circuit studies and relay application studies; and others. In January 1929 he was transferred to the Alabama Power Company, Birmingham, under an engineering exchange agreement. While here he worked on studies for new power stations, substations, and transmission lines. In July 1929 he was called back to Schenectady and assigned to take part in preparation of engineering studies and specifications for a 3,000-volt d-c electrification of the Trans-Caucasian Railway, Russia. In November 1929 he was assigned to the engineering office in Moscow, Russia, and was closely associated with the construction of the Dnieprostroy Hydroelectric Power Station in the Ukraine and the electrification of the Trans-Caucasian Railway. During his stay in Russia, he was responsible for central station, industrial, and railway engineering application, and consultations related to it. In 1934 he returned to New York with the International General Electric Company where he worked on application engineering and equipment selection for proposals relative to export. This included equipment for central stations, substations, and transmission lines. In January 1942 the Brazilian government sent an engineering mission to the United States to engage a consulting engineering firm and purchase machinery, equipment, and materials for the construction of a large, modern steel mill at Volta Redonda, Brazil. Mr. Trone was loaned to the steel company to prepare complete and final detailed electric installation layout and power distribution drawings and to prepare complete bills of materials. In August 1944 he returned to General Electric from Brazil to report on the engineering work done, and in November of that year returned to Rio de Janeiro to join the staff of General Electric S. A. permanently as technical assistant. During a 5-year period, Mr. Trone was responsible for all application engineering in the electric apparatus field. Some of his projects at this time were a study for the solution of a voltage regulation problem on the power supply system of the largest electrified railway of Brazil; supervision of the construction of the first television transmitter and studio installation of Rio de Janeiro; and installation of large a-c to d-c conversion equipment at the power station in one of Brazil's northern ports. In January 1950, Mr. Trone was appointed chief engineer of General Electric S. A. With this appointment, his former duties continued with the additional duties of engineering responsibility in work of the electronics department, lighting department, service department, and merchandizing department. Mr. Trone is a member of Sigma Xi, Association of Iron and Steel Engineers, Society of American Military Engineers, and Brazilian Technical Standards Association.

William W. Wishard (AM '26, M '40), electrical engineer, Commonwealth Edison Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions and originality in the application of high-voltage subtransmission systems to high-density load areas, and for sound engineering judgment and able leadership of an engineering organization of a large utility system." Mr. Wishard was born in Bloomfield, Iowa, September 10, 1893, and graduated from Iowa State College in 1919 with a bachelor of science degree in electrical engineering. After spending a year with the San Joaquin Light and Power Company, Fresno, Calif., he entered the engineering department of Commonwealth Edison Company in 1920. In 1924 he was made assistant chief draftsman. After leaving the drafting division in 1927, he was a field engineer for 5 years and a supervising field engineer for an additional 5 years. During this period a system of industrial substations on the customer's premises supplied by 12,000-volt loop

feeders from generating stations and distribution centers was initiated and developed by Mr. Wishard. He also supervised construction of the initial low-voltage a-c network system for the supply of the high-density area of downtown Chicago. Original design features incorporated in the network system were unique supports for long vertical cables; transformer manhole designs to provide adequate ventilation; and safety features and a supervisory control system for monitoring the transformer loads at a common dispatching office. In 1937 Mr. Wishard was placed in charge of a section of the Engineering Department, responsible for the issuance of orders for and engineering supervision of electric installations in generating and distributing stations, transmission terminals, substations, industrial substations, network vaults, and transformer vaults. From 1943 until 1950, Mr. Wishard was station design engineer, in charge of a division of the engineering department responsible for general designs, installation specifications, and engineering supervision of all electric plant facilities, and for structural and mechanical plant as assigned, in generating and distributing stations, transmission terminals, substations, industrial substations, network vaults, and transformer vaults. During this period of development, 555,000 kw of new generation were added to the system which included a new generating station of 300,000 kw initial capacity incorporating a completely centralized electronic combustion control system. In May 1950 he became assistant chief electrical engineer. During this period he developed a new subtransmission system to supply the fast growing load of the company. Distributing stations in remote load centers were built and supplied by 69-kv subtransmission lines. He became electrical engineer in 1952 responsible for supervision and administration of transmission, distribution, generating, system planning, and drafting divisions of the engineering department. Mr. Wishard is a member of the Western Society of Engineers and has served on the AIEE Committee on Rotating Machinery (1949–52).

John C. Woods (AM '23, M '31), station design engineer, Commonwealth Edison Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for contributions in the field of electrical control of large turbogenerators and improvements in substation design contributing to their reliability and economy." Mr. Woods was born in Grayson, Ky., October 26, 1896, and attended Westinghouse Technical School and Armour Institute of Technology. In May 1924, he started with the Commonwealth Edison Company as a draftsman, and in 1926 was put in charge of the drafting section concerned with d-c substations. In 1929 he was made electrical designer with responsibility for the physical design of all d-c substations of the company, including selection of equipment. Incorporated in the design of these substations were several original features which included a 1-way relay contact for signal purposes and a circuit for determination of current unbalance due to circuit breaker contact resistance. From 1936 to 1940, as design engineer, he was responsible for making engineering studies of system extensions and maintenance, basic design of specific projects, equipment selection, cost estimates, and general supervision of the preparation of drawings and approval of drawings for substations. In 1940 he became supervising design engineer, directing the work of a group of design engineers preparing electrical plans and specifications for all new generating stations and distributing stations and for additions to existing stations on the company's system. Three outstanding examples of important basic engineering designs developed by Mr. Woods during this period were a large isolated-phase 15-kv switchhouse and 69-kv outdoor terminal in which great efficiency in space utilization and considerable improvement for safety and operation were incorporated; the use of prefabricated unit-type relay switchboard panel; and the use of standard basic elements for training cable in trays. From 1943 to 1944 Mr. Woods was on leave of absence from the Edison Company and assigned a position with Sargent and Lundy as an electrical designer and installation supervisor of the construction of a large steam generating station for the Manhattan District of the Atomic Energy Project, Oak Ridge, Tenn. The design of this plant required the installation of a large number of independently operated turbogenerators with strict requirements for unusually accurate frequency control and for instantaneous automatic transfer of reserve generators to replace any unit in trouble. Resuming his position as supervising design engineer in the station design division between 1944 and 1950 he was in charge of the electrical design for all generating and distributing stations. Mr. Woods developed original designs for a compact and flexible means of supporting cables in vertical shafts and a grid-controlled thyratron rectifier for governor operation. In 1950 he became station design engineer, supervising and co-ordinating the structural, mechanical, and electrical designs of generating, distributing stations and substations. Mr. Woods has been responsible for the development of a new outdoor-type substation and further improvements in the basic design of large turbogenerator installations. Mr. Woods has served on the Institute Committees on Switchgear (1947–53) and Membership (1946–53, Chairman 1950–52).

AIEE PERSONALITIES.....

F. M. Farmer (AM '02, F '13, Member for Life), president, Electrical Testing Laboratories, New York, N. Y., has retired after nearly 50 years continuous service with the company. He continues on the board of directors of which he has been elected honorary chairman. He has been president since 1949, having served previously as chief engineer and vice-president of the laboratories. An 1899 mechanical engineering graduate of Cornell University, he worked in the Testing Department of the General Electric Company, Schenectady, N. Y., for 18 months after his graduation. During the years 1902–06, he was an instructor in electrical measurements and physics in the Night School of Science, Cooper Union Institute, New York, N. Y. He has been associated with Electrical Testing Laboratories since 1903. Mr. Farmer has been extremely active in engineering organizations. He is a member of the American Association for the Advancement of Science and The American Society of Mechanical Engineers. He is a past president of the AIEE (1939–40), the American Society for Testing Materials, the American Welding Society, and the United Engineering Trustees. He has been chairman of the Engineering Foundation and the American Standards Association Standards Council. Mr. Farmer served as a director of the Institute (1934–38) and vice-president (1938–39). Some of the committees on which he has served are Standards; Board of Examiners; Transmission and Distribution; Electric Welding; Research; Technical Program; Award of Institute Prizes; Executive; Edison Medal; Finance; Planning and Co-ordination; Publication; and Constitution and Bylaws.

J. D. Tebo (AM '36, F '51), associate editor, Bell Telephone Laboratories, New York, N. Y., has been appointed editor of the *Bell System Technical Journal* and of the *Bell Laboratories Record*. Born July 5, 1903, in Harpers Ferry, W. Va., Dr. Tebo received the degrees of bachelor of engineering in 1924 and doctor of engineering in 1928 from Johns Hopkins University. In 1924 and 1925 he took the student training course in meter and relay operating at the Westinghouse Electric Corporation, East Pittsburgh, Pa. His asso-

F. M. Farmer

J. D. Tebo

ciation with Bell Telephone Laboratories began in 1928, at which time he was engaged in electromagnetic design. In 1938 he was put in charge of the machine switching laboratory. During World War II he was concerned with the development and manufacture of radar and sonar equipment for use by the Armed Forces. Following the war he returned to machine switching and in 1949 became science editor of the *Bell Laboratories Record*. Active in the affairs of the Institute, Dr. Tebo was chairman of the New York Section (1950–51); chairman of the Committee on Basic Sciences (1946–48); Science and Electronics Co-ordinating Committee (1948–49), and Science and Electronics Division Committee (1949–50). He is presently a member of the Publication Committee and Vice-Chairman of the Committee on Technical Operations. Mr. Tebo is a member of Sigma Xi.

OBITUARY • • • • • •

Gano Dunn (AM '91, M '94, F '12, HM '45, Member for Life), president, J. G. White Engineering Corporation, New York, N. Y., and a former president of the AIEE, died April 10, 1953. Dr. Dunn was born in New York, N. Y., October 18, 1870. He received a bachelor of science degree from the College of the City of New York in 1889 and 2 years later had the distinction of receiving from Columbia University the first degree in electrical engineering awarded in the United States. After several years in the communications and electrical engineering field, Dr. Dunn joined J. G. White Engineering Corportation, New York, N. Y., in 1911 as vice-president in charge of engineering and construction. Two years later he was elected to the presidency of the company and the corporation became one of the most prominent construction firms in the world. Among the projects constructed were the United States Naval Oil Base at Pearl Harbor, the steam plant at Muscle Shoals, Ala., 13 transoceanic radio stations, the original Government aviation station at Langley Field, Va., and the first long-distance natural gas pipe line in California, as well as completing programs of roads, oil, and irrigation in Latin America. Dr. Dunn was elected to the board of directors of the Radio Corporation of America in 1938. He was chairman of trustees and former president of Cooper Union for Advancement of Science and Art. He was a trustee of Barnard College and a member of the visiting committee of Harvard Engineering School. He was a member of the late President Roosevelt's Science Advisory Board. Among the many awards presented to Dr. Dunn were the Townsend Harris Medal of the College of the City of New York, the Thomas A. Edison Medal of the AIEE (1937), the Egleston Medal of Columbia University, the Hoover Medal of the National Engineering Societies (1939), Modern Pioneer Award of the National Association of Manufacturers, and the Peter Cooper Medal of the Cooper Union. Dr. Dunn received honorary degrees of doctor of science from Columbia University, Rutgers University, and New York University. In 1947, Bowdoin College presented Dr. Dunn with a doctor of laws degree. Dr. Dunn was a fellow of the Institute of Radio Engineers, the Royal Microscopy Society, and the New York Academy of Sciences. He was honorary secretary for the United States of the Institution of Electrical Engineers of Great Britain, a member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, Optical Society of America, American Academy of Arts and Sciences, American Philosophical Society, and others. He was also a member of Phi Beta Kappa and Sigma Xi. An exceptionally active member

Gano Dunn

of the AIEE, Dr. Dunn had served as president (1911–12), vice-president (1900–02, 1905–07), and manager (1897–1900, 1902–05), and on the following Institute committees: Code of Principles of Professional Conduct (1914–19); Iron and Steel Industry (1914–16); Public Policy (1914–17, 1920–30, Chairman 1925–27); Edison Medal (1922–27, 1932–37, Chairman 1924–27); Education (1925–26); Hoover Medal Board of Award (1931–39); and many other committees in co-operation with other engineering societies. The Council of the Institution of Electrical Engineers, through its secretary, Mr. V. K. Brasher, has expressed its deep regret on the passing of Dr. Dunn in the following letter from Mr. Brasher to Mr. R. H. Barclay of the J. G. White Engineering Corporation: "He was, of course, known personally to several members of the Council and those who had not had the privilege of meeting him knew of his outstanding work not only for The Institution but also in the cause of Anglo-American friendship. He was known to many members of The Institution, a substantial number of whom have reason to be thankful to him for the advice and help he so readily gave them when, strangers as they were in a new country, they turned to him for guidance. The Council feels that it would be difficult to find anyone with qualities so ideally suited to the Office which he held and that his passing leaves a gap which it will be difficult for them to fill. They would appreciate it greatly if you would be so kind as to convey a meassage of their deep sympathy to Gano Dunn's next-of-kin and also, if you think fit, to his many business associates and friends in the AIEE."

Per Engelbert Erikson (M '24, F '28), retired, Malmo, Sweden, died December 7, 1952. Mr. Erikson was born in Malmo, September 28, 1880, and received the degree of electrical engineer from the Royal Institute of Technology, Stockholm, in 1903. He then joined the Western Electric Company, New York, N. Y., to do developmental work on loading coils and balanced toll cables. He was transferred to London, England, in 1909 as European transmission engineer. He had charge of the systems planning of the first loaded long-distance cable installed in Europe, which linked London and Birmingham, England. In 1916 he returned to New York City to continue with transmission studies and design work. During 1918 he supervised the reconstruction of the telephone transmission line between Rio de Janeiro and São Paulo, Brazil, the first in Brazil to be equipped with repeaters and and loaded toll entrance cables. Mr. Erikson returned to London in 1919 to what was then the International Western Electric Company and was to become the International Standard Electric Corporation in 1925. In 1928 he became assistant vice-president in charge of the technical division of the European commercial department. From 1930 to 1932 he was European chief engineer. In 1940 Mr. Erikson was transferred to Sweden as liaison officer between New York and affiliated companies in Scandinavia. He returned to London in 1946 as technical advisor to the European commercial department. From 1938 to his retirement in 1950, Mr. Erikson served as a director of A. B. Standard Radiofabrik of Stockholm. Starting in 1924 he was active in the International Consultative Committee on Telephony. Since 1929 he served as a delegate for the operating companies, becoming secretary in 1934. He was a member of the Institution of Electrical Engineers, Great Britain, and the Svenska Teknologföreningen.

Harry Lepper Kirker (AM '03, M '06, F '13, Member for Life), retired, died April 2, 1953. Mr. Kirker was born in Catlettsburg, Ky., March 4, 1866, and graduated from Ohio State University in 1889 with a bachelor of science degree. He joined Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation) in Pittsburgh, Pa., in 1890, and was retired on reaching the company's age limit in 1931. During this period he also worked for the Bed Rock Dredging Corporation, Boise Basin, Idaho, and the French, British, and Norwegian Westinghouse companies. His work was largely in the field and pertained to railway electrifications and power plants. At the factory he worked with the testing department and student course and later with projects and reports. He was resident engineer for the British Westinghouse Company on the London Metropolitan Railway electrification and the Mersey Tunnel Railway electrification at Liverpool. He was also resident engineer for the Grand Trunk Railway St. Clair Tunnel electrification at Port Huron, Mich., and Sarnia, Ontario, Canada. He was a member of the Engineers Society of Western Pennsylvania, the American Transit Association, the American Association for the Advancement of Science, and many pomological societies.

Royce Allen Beckman (AM '13, M '27, F '49, Member for Life) retired, died April 1, 1953. Mr. Beckman was born in St.

Louis, Mo., July 19, 1888, and was graduated from the University of Missouri in 1910 with a degree of bachelor of science in electrical engineering. He had been employed at the General Electric Company for 42 years when he retired on August 1, 1952. At the time of his retirement he was manager of the federal and marine engineering division. Mr. Beekman entered the General Electric Company's student test course in July 1910 and transferred to the Marine Engineering Department in February 1912. For most of his career, Mr. Beekman was associated with marine activities and held a number of patents relating to electric ship propulsion. He was active in the application and installation of electric propelling machinery on the *Lexington*, *Saratoga*, and other United States Naval vessels. He was a member of Tau Beta Pi and the Society of Naval Architects and Marine Engineers. Mr. Beekman had served on the following AIEE committees: Application to Marine Work, Marine Transportation (1919–50, Chairman 1930–33); Standards (1939–41, 1942–48); and Technical Program (1930–33).

Carl Edward Johnson (AM '09, M '19, F '25, Member for Life), chairman of the board, Sterling Electric Motors, Inc., Los Angeles, Calif., died March 26, 1953. Mr. Johnson was born in Chicago, Ill., October 6, 1883, and moved to San Francisco, Calif., in 1903. Two years later he moved to Los Angeles where he was in charge of redesigning and rebuilding electric machinery for Woodill and Hulse Electric Company. In 1906 he organized the Dynamo Electric Machine Company and engaged in the manufacture of electric motors. In 1908 he organized the U. S. Electrical Manufacturing Company which absorbed the Dynamo Electrical Machine Company. From 1906 to 1927 Mr. Johnson made many major technical contributions to the electric motor field, being directly responsible for approximately 30 patents. In 1927 he founded Sterling Electric Motors, Inc., and added 25 patents on electric apparatus to his list of inventions. He recently had received a 50-year certificate from the National Electrical Manufacturers Association in recognition of his services to the electrical industry. Mr. Johnson had been a member of the AIEE Committee on Electrical Machinery (1938–39, 1940–41).

Richard Edmund Brown (AM '17, M '34, Member for Life) retired, died March 26, 1953. Mr. Brown was born in Friedensburg, Pa., October 18, 1886, and received his bachelors degree in electrical engineering from Lehigh University in 1910 and his masters from Cornell University in 1916. From 1911–1912 he was employed by the Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation). He was an instructor in physics and mathematics at Bryant and Stratton College, Buffalo, N. Y., from 1913 to 1915. He became an instructor in electrical engineering at the University of Pennsylvania in 1917, becoming an assistant professor in 1922. In 1929 he joined New York University, New York, as associate professor of electrical engineering, becoming acting head of the department of electrical engineering in 1932, and head of the department in 1935. He retired in 1939. He was a member of the American Association for the Advancement of Science and had served on the AIEE Committee on Electrical Machinery (1921–24).

Bernard Waldo Wallace (AM '47, M '52), regulation engineer, Toledo (Ohio) Edison Company, died April 18, 1953. Mr. Wallace was born at Fairmount, Ill., July 27, 1900, and graduated from Purdue University with a bachelor of science degree in mechanical engineering in 1923. Following his graduation he joined the Toledo Edison Company as a junior engineer. Upon completion of his training course, he was assigned to the results engineering department in 1924. In 1927 he was transferred to the distribution engineering department. In 1928 he was sent to Long Branch, Mich., to take over as acting manager of the Long Branch Light and Power Company. He returned to the estimating division of Toledo Edison in 1929 and was promoted to regulation engineer in 1935. He served the Institute as a member of the Toledo Section Executive Committee for several years. He was a member of the Ohio Society of Professional Engineers.

Johnston H. Hunt (AM '45), planning and design engineer, Toledo (Ohio) Edison Company, died March 17, 1953. Mr. Hunt was born in Somerset, Ohio, November 1, 1892, and received his bachelor of science degree in electrical engineering from Ohio State University in 1918. During World War I, he served as a second lieutenant in the signal corps. In 1919, Mr. Hunt joined the Toledo Railway and Light Company, the forerunner of the Toledo Edison Company, as a cadet engineer. In 1921 he was transferred to Cities Service Power and Light Company, New York, N. Y., as a statistician. He returned to the Toledo Edison Company in 1922 as an engineer. In 1950 he was promoted to planning and design engineer. He was a member of the Edison Electric Institute and the Association of Edison Illuminating Companies.

William Seymour Hadaway, Jr. (AM '94, M '96, F '13, Member for Life), retired, died April 12, 1953. Mr. Hadaway was born in Plymouth, Mass., August 24, 1866, and received his bachelor of science degree in physics from Massachusetts Institute of Technology in 1887. Mr. Hadaway had devoted his professional life to the improvement of electric heating appliances for industrial use and held more than 150 patents.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of April 16 1953, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Bastian, A. L., project engineer, Ward Leonard Electric Co., Mount Vernon, N. Y.
Crain, C. M., associate professor of electrical engineering, University of Texas, Austin, Tex.
Crest, W. M., supervising engineer, Public Service Co. of Northern Illinois, Chicago, Ill.
Crooks, J. C., supervisor of work standards, Allison Div., General Motors Corp., Indianapolis, Ind.
Daroff, M. A., electrical engineer, U. S. Naval Air Development Center, Johnsville, Pa.
Fry, M., staff member, The Johns Hopkins University, Chevy Chase, Md.
Grosskurth, R. A., assistant command electrical officer, Royal Canadian Navy, Nova Scotia, Canada
Hadwin, T. F., substations superintendent, British Columbia Electric Railway Co., Ltd., Vancouver, British Columbia, Canada
Hamner, F. G., distribution engineer, Southern Services, Inc., Birmingham, Ala.
Hartman, A. E., instructor, Case Institute of Technology, Cleveland, Ohio
Heil, H. R., engineer, Columbus & Southern Ohio Electric Co., Columbus, Ohio
Hrovath, J. W., staff electrical engineer, Aluminum Co. of America, Cleveland, Ohio
T. K. Jefferis, Village Mgr., Grosse Pointe Shores, Mich.
Johnson, E. F., manager, commercial engineering dept., Clark Controller Co., Cleveland, Ohio
Johnson, W. M., supervisor, forced-cooled transformer engineering, General Electric Co., Pittsfield, Mass.
Kawecki, E., application engineer, General Electric Co., Schenectady, N. Y.
Lauhacher, W. F., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Leonard, L. V., system operator, Public Service Co. of Indiana, Inc., Plainfield, Ind.
Lincoln, E. W., manager, production planning, Fansteel Metallurgical Corp., North Chicago, Ill.
Mason, L. L., general foreman, Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Means, C. P., asst. research engineer, Bendix Radio Div., Bendix Aviation Corp., Towson, Md.
Money, L. J., member of technical staff, Hughes Aircraft Co., Culver City, Calif.
Nix, R. C., electrical engineer, Tennessee Valley Authority, Knoxville, Tenn.
Pizzorno, P. P., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Powers, W. R., design engineer, General Electric Co., Fort Wayne, Ind.
Robbins, P. H., supt. of engineering, Metropolitan Edison Co., Reading, Pa.
Roberts, H. N., owner & manager, H. N. Roberts & Associates, Lubbock, Tex.
Sanderford, R. B., district engineer, Tennessee Valley Authority, Nashville, Tenn.
Schechter, M., electrical engineer, P. R. Moses & Associates, New York, N. Y.
Scorgie, D. G., physicist, Naval Research Laboratory, Washington, D. C.
Smith, L. M., electrical engineer, Bonneville Power Administration, Portland, Oreg.
Staats, G. W., engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Stuart, M. J., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Taylor, G. E., senior engineer, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
TeWinkle, G. J., electrical engineer, Niagara Mohawk Power Corp., Buffalo, N. Y.
Thompson, J. R., sales engineer, Garland-Affolter Engineering Corp., Portland, Oreg.
White, H. F., senior electrical engineer, Jackson & Moreland, Boston, Mass.
Zansie, C. E., electrical engineer, Sargent & Lundy, Chicago, Ill.

38 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before June 25, 1953, or August 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Garrard, C. J. O., General Elec. Co. Ltd., Witton, Birmingham, England
Nelson, P. E., Chas. T. Main, Inc., Boston, Mass.
Ross, J. H., Consulting Engineer, 1251 Yonge St., Toronto, Ontario, Canada
Young, H. E. (re-election), American Locomotive Co., Schenectady, N. Y.

4 to grade of Member

OF CURRENT INTEREST

Television Microwave Equipment Provides Simultaneous Picture-Sound Relaying

Two new television microwave equipments were announced recently by the Raytheon Manufacturing Company. These are the first of a series of microwave and other communications products which are planned to meet the expanding requirement for equipment of advanced and flexible design in the communication industry.

One of these new units is the *KTR-100* "Microlink," a compact, lightweight relay developed for use as a studio transmitter link, remote, interconnecting, radar relaying, or other broadband requirements. The other is the new *MTR-50* "Magnalink," a much larger link with great power for extended range and maximum fade protection.

The new *KTR-100* Microlink in addition to providing audio and video includes a completely new automatic frequency control and limiter, special cable compensating switch allowing use of up to 500 feet of cable, accurately controlled transmitter frequency, built-in voltage regulator, and provisions for frequency and modulation monitoring.

A new temperature-controlled fused quartz cavity, accurate to ±1/2 megacycle over the system operating range of −30 to +50 degrees centigrade, allows much greater frequency sensitivity and control.

Mechanical design is the most flexible and advanced yet offered to the industry. The complete system may be assembled or disassembled in a matter of minutes. Greater accessability of components and built-in provisions for testing the system during operation are added features in Microlink.

The equipment operates in the frequency range of 6,875 to 7,125 megacycles, with a power output of 0.1 watt. Input voltages are standard 115 volts alternating current. The entire system, composed of four suitcase-type cases and two parabolas, weighs less than 200 pounds.

Microlink operator "zeroes in" his parabola from an upper story of the John Hancock building in Boston, on the opposite unit which is set up on Mount Wachusett in western Massachusetts. Contact was made within a matter of seconds, and a strong, clear signal was received. The straight-line distance between units was approximately 40 miles

The model *MTR-50* Magnalink, a similar but much larger link, operates in the 2,000-megacycle frequency range, and is powered by a 50-watt magnetron. By virtue of normal gain factors through a 10-foot parabola the 50-watt tube output is multiplied resulting in erp (effective radiated power) of 50,000 watts.

Microlink's ease of assembly is demonstrated here as a Raytheon engineer fits the transmitting unit to its parabola. Machined guides assure a quick and perfect alignment, and the junction is watertight. The entire integrated unit is light enough to be picked up and moved about on a rooftop by one man

The Magnalink, used as a single hop relay over a 140-mile path in the atomic tests at Yucca Flats, Nev., also utilizes a system of multiplexing the audio and video signals without deterioration of quality. Frequency stability is maintained within ±.05 per cent by automatic thermostatic control of the magnetron body temperature. Video frequency response is flat within ±1.5 decibels to 6 megacycles and 100-per-cent modulation can be obtained with input signals as low as 0.3 volt peak-to-peak.

All important circuits in both transmitter and receiver are individually metered and test points are provided for pertinent video circuits.

The Magnalink receiver is of the single superheterodyne type employing a *2K28* reflex klystron as a local oscillator and a *1N21-B* crystal mixer. The intermediate-frequency amplifier incorporates one low noise input stage, two limiters, and auto-

Future Meetings of Other Societies

American Management Association. General Management Conference. June 17–19, 1953, Hotel Statler, New York, N. Y.

American Society for Engineering Education. Annual Meeting. June 22–26, 1953, University of Florida, Gainesville, Fla.

American Society for Testing Materials. Annual Meeting. June 29–July 3, 1953, Chalfonte-Haddon Hall Hotels, Atlantic City, N. J.

American Society of Heating and Ventilating Engineers. Semiannual Meeting. June 29–July 1, 1953, Shirley-Savoy Hotel, Denver, Colo.

American Welding Society. Spring Technical Meeting and Welding and Allied Industry Exposition. June 16–19, 1953, Shamrock Hotel, Houston, Tex.

Conference of Basic Materials and Exposition of Basic Materials for Industry. June 15–19, 1953, Hotel Roosevelt and Grand Central Palace, New York, N. Y.

Congress of Radiology. 7th International Congress. July 19–25, 1953, Copenhagan, Denmark

Edison Electric Institute. 21st Annual Convention. June 1–4, 1953, Atlantic City, N. J.

International Union of Pure and Applied Physics. Colloquium on Cosmic Rays. July 5–11, 1953, Bagneres de Bigorre, France

International Union of Pure and Applied Physics. International Congress on Electroacoustics and Symposium on the Sound Insulation of Light-Weight Structures. June 16–24, 1953, The Hague, Hilversum, Delft, and Eindhoven, Netherlands

National Society of Professional Engineers. Annual Meeting. June 18–20, 1953, Sheraton-Beach Hotel, Daytona Beach, Fla.

Pan American Railway Congress Association. 8th Pan American Railway Congress. June 12–20, 1953, Washington, D. C., and June 21–25, 1953, Atlantic City, N. J.

Society of Automotive Engineers. Summer Meeting. June 7–12, 1953, The Ambassador and Ritz Carlton, Atlantic City, N. J.

The American Society of Mechanical Engineers. Semiannual Meeting. June 28–July 2, 1953, Hotel Statler, Los Angeles, Calif.

matic gain control. Intermediate frequency is 130 megacycles and bandwidth 17 megacycles. Output signal variations under widely varying input signal conditions are prevented. Two output stages provide video outputs of up to 2 volts peak-to-peak. The video bandwidth is flat within ±1.5 decibels to 6 megacycles.

This equipment embodies straightforward circuitry with ease of accessability of all components. All power supplies are electronically regulated.

Jet Pilotless Drones Collect Data on Radiological Hazards in Atomic Clouds

Details were released recently by the United States Air Force and the Sperry Gyroscope Company of the robot system used to control the Lockheed *QF-80* pilotless drone aircraft participating in the nuclear tests now taking place at the Nevada Proving Grounds.

The *QF-80* drones, a pilotless version of the standard Lockheed *F-80* jet fighter, will collect data of vital interest to the United States Air Force regarding radiological hazard in an atomic cloud.

A robot system of the Sperry Gyroscope Company completely controls via remote means the *QF-80*. The system enables "NULLO" flight (no live operator aboard) by the *QF-80* under direction by radio and radar from the beep-box control signals from two ground stations worked by specially trained "beep pilots," or from a nearby jet "director" aircraft.

The pilotless jet takes off and lands itself, and firmly holds any compass course, altitude, or speed. While air-borne it maneuvers easily, from take-off speed to Mach limit, and from sea level to 40,000 feet. The *QF-80* corrects itself for any unwanted deflections and holds constant air speeds, even while automatically adjusting for nose-up or nose-down angles of flight. Accurate control can be maintained up to full capacity of the aircraft, through take-offs and climbs, dives, level flight, flat turns, and bank turns.

Pilotless aircraft now are found in several diversified applications as: a target drone for weapon testing, evaluation, and radar tracking; a data-gathering vehicle for use in tests such as at the Nevada Proving Grounds or in special structural tests, both types presenting hazard to human life if manned aircraft were employed; a target drone for weapon testing, evaluation, and radar tracking; a training vehicle capable of both manned and remote-control flight for instruction of drone-director crews; and as a research tool to penetrate hitherto unexplored aerodynamic and physical regions without hazard to human life.

One vital element of the *QF-80* system is the Sperry *E-4* precision autopilot, similar to the one which automatically flies long-range jet bombers on precision courses.

The remote control system of the *QF-80* provides a degree of exact, automatic control of jet air speeds not attainable before. Such stabilized air speeds is a critical matter in landings and precision maneuvers. The use of drones in atomic tests in Nevada demonstrate the progress made in "mating" radio, radar, gyroscopes, and servomechanism into integrated systems of flight control.

A typical *QF-80* mission step-by-step follows:

The ground "beep pilot" takes his station on a platform near the runway, before a little black box equipped with switches, push buttons, and lights. One switch has a long handle, resembling a miniature airplane control stick. Off at one side are the radio receivers and transmitters and power generators.

When the pilotless jet is lined up on the runway, the beep pilot checks various controls through his black box, and control surfaces of the airplane move instantly in response. He pushes one button for automatic take-off sequence, then "beeps in" throttle increase by triggering a switch in short pulses. Another button releases the brakes, and as the drone gathers speed, the ground pilot beeps in left or right signals to hold the jet to the center of the runway.

Further stages of the take-off are completely automatic. At 110 miles per hour, preset climb is introduced. At 150 miles per hour, the landing gear retracts. At 160 miles per hour, the wing flaps also retract, and the pilotless craft is air-borne. From this point on, control may be passed, if desired, at any time to another beep pilot with more compact but similar controls in a *DT-33* director airplane.

United States Air Force photo

Air Force mechanics at Indian Springs Air Force Base are shown calibrating radio-control equipment in a Lockheed QF-80 drone (pilotless aircraft) which was used in penetrating a radioactive cloud resulting from an atomic detonation during a recent nuclear test at the Nevada Proving Ground

Oak Ridge Summer Symposium to Be Devoted to Modern Physics

The Fifth Annual Oak Ridge Summer Symposium will be devoted to modern physics this year after 3 years dealing with other fields of science. The symposium will be held from August 24 to August 29, 1953, and will consist of several lectures within the general fields of mesons and ultra-high-energy phenomena on the one hand and electromagnetic radiations on the other.

Speakers on the symposium will include: Jesse W. Du Mond, California Institute of Technology; Ralph Livingston, J. Rand McNally, and T. A. Welton of the Oak Ridge National Laboratory; M. Stanley Livingston, Massachusetts Institute of Technology; and J. Steinberger, Columbia University. Specific subjects to be covered include mesons, cosmic rays, microwave, infrared, and optical spectra, gamma-ray spectroscopy, quadrupole moments, and quantum electrodynamics.

This will be the second in the series of Oak Ridge summer symposia to be devoted to modern physics. The first symposium 5 years ago was concerned with this field, and subsequent gatherings have been devoted to a review of modern chemistry and discussions of the role of atomic energy in engineering and in agriculture.

The symposia are sponsored jointly by the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies. Additional information may be obtained from the University Relations Division of the Institute, P. O. Box 117, Oak Ridge, Tenn.

Occupational Safety Guide Lists Accident Prevention Aids

The National Safety Council's new Occupational Safety Service Guide provides company safety directors with a complete catalogue of the many and varied accident prevention aids available from the Council.

In the service guide, company safety men will find not only the tools they need to build their plant safety programs, but also the training aids available for instructing supervisors and workers.

For the safety man, the guide offers the Council's periodicals, newsletters, and a complete library of technical and administrative publications covering all phases of occupational accident prevention. Information on the subjects covered in the basic and advanced courses of the Council's Safety Training Institute also is included.

To assist the foreman, the service guide offers a monthly magazine, 24 training films that show supervisors how to use basic human traits in building a better safety program, and several hundred made-to-order 5-minute safety talks.

A full line of posters, films, and booklets

are available to sell safety to the man on the job.

Copies of Service Guide *2.1* can be obtained without cost by writing the National Safety Council, 425 North Michigan Avenue, Chicago 11, Ill.

Screw Thread Manual Contains American and Unified Standards

According to George T. Trundle, Jr., Chairman, Board of Directors, Trundle Engineering Company, an important and necessary handbook has been published by The American Society of Mechanical Engineers (ASME), culminating 50 years of argument, conference, and compromise.

Titled "ASME Screw Thread Manual," it is a shop and drafting room abridgement of the American and Unified Standards for screw threads and their gauges. The volume contains the American standards and those that were set by the Accord of 1948 signed by Canada, Great Britain, and the United States. The agreement was designed to assure the interchangeability of screws and threaded products of those nations.

The book should be of value to every engineer and draftsman who deals with threaded screw parts.

The "ASME Screw Thread Manual" may be obtained from the ASME Order Department, 29 West 39th Street, New York 18, N. Y., at a price of $2.50 per copy.

Atomic Energy Converted to Electricity in Power Test

The homogeneous reactor at Oak Ridge (Tenn.) National Laboratory produced usable amounts of electric power on February 24, 1953, when it was brought to its full design operating load of 1,000 kw. The occasion was marked with ceremonies befitting the successful operation at full load of the first reactor of this type with a power potential as well as the second instance of the production of electricity from atomic energy in this country. The other such instance was in a heterogeneous reactor at Arco, Idaho, in December 1951.

The homogeneous reactor will produce both electricity and fissionable material, making it of great interest in view of the impending development of dual-purpose reactors. The solution itself serves as the coolant. It is pumped through a heat exchanger to produce steam, which in turn drives a turbine-generator to produce electricity.

The Oak Ridge reactor went critical on April 15, 1952, construction on it having begun in March 1951. The reactor underwent a thorough period of testing at low power before being tested at full power. Experimental work will continue at high power to acquire information regarding the feasibility of this type for full-scale reactors. For the first short period of top-power level operation, the reactor produced twice as much electricity as needed by its own building and the excess was fed into the Oak Ridge National Laboratory electric system. At full operation 150 kw of electricity was produced.

Announcement of the successful project was made jointly by the Atomic Energy Commission and the Union Carbide and Carbon Corporation, which operates the Laboratory.

New Metal Detector to Protect Crushing Machinery Announced

A new metal detector especially engineered to meet the needs of quarries, coal mines, and other mining-type industries for the protection of crushing machinery has been developed by the Industrial Equipment Section of the RCA Victor Division, Radio Corporation of America.

The new equipment, which normally would be installed between the primary and secondary crushing operations, consists of two units—the detector itself framing the aperture through which will pass the conveyor carrying the product being inspected, and a small control unit.

The detection aperture is fashioned to suit a variety of primary belt conveyors, and the frame is so designed that it can be separated into two parts for installation and rejoined around the belt. The aperture is completely weatherproof to permit outdoor operation. The inspection coils are adjusted so that the equipment will detect any pieces of tramp metal, magnetic or nonmagnetic, large enough to damage the crushing machinery, but will not stop operations for small unobjectionable metal objects.

The electrical change induced by the passage of metal through the aperture of the new equipment can be used to activate any kind of signaling device, or to stop the conveyor belt to prevent the tramp metal from reaching the second crusher. The detector will give satisfactory performance at conveyor speeds of up to 600 feet per minute, the company stated.

Only two controls are needed to operate the equipment. The control unit is connected to the detector by means of a 3-conductor metal-shielded cable. This unit is easily portable, measuring $8\frac{1}{4}$ inches high, $6^{3}/_{4}$ inches wide, and 10 inches long, and weighing only about 20 pounds. The equipment operates on 115 volts, 50 to 60 cycles, and consumes approximately 70 watts.

Special Summer Programs Are Announced by MIT

Massachusetts Institute of Technology (MIT) has announced special summer courses in transistors, digital computers, feedback control systems, and an advanced course in fluid power controls for 1953.

The program in "Transistors and Their Applications" will be held from July 20 to 31. Approximately one-fourth of the program will be devoted to a development of the theory of the operation of transistors, starting from physical principles. A portion of the program will be devoted to laboratory experiments and attention will be focused on the ultimate possibilities of the transistor for the solution of engineering problems.

The potentialities of modern electronic processing systems will be emphasized during the program on "Digital Computers and Their Applications" from August 24 to September 4. The program is especially designed for those unfamiliar with digital computers who must determine how computing systems can be applied to their problems and the advantages that might accrue. No previous training or experience beyond a bachelor's degree in business, science, or engineering will be required.

The special program presenting a formalized theory for the analysis and synthesis of "Feedback Control Systems" will be given from June 22 to July 3. The first week of the MIT course will be devoted to a review of the theory of measurement and feedback control. The second week will deal with advanced subjects, such as contactors, pulse control mechanisms, data sampling, distributed parameter systems, pneumatic and thermal systems, random signals and loads, and nonlinear systems.

The advanced course in fluid power controls will be given from July 6 to 17 and is designed especially for engineers whose work is in some phase of the fluid power controls field. Highlights of the program will include discussions of the fundamentals of fluid flow, new concepts of flow valve performance and design, and the generation and utilization of compressible and incompressible fluid power. Analytical and simulation techniques for studying the dynamics of valve-controlled systems will be discussed, and there will be appropriate laboratory demonstrations. Enrollment will be limited to those whose industrial and educational experience will enable them to contribute to and benefit from the program.

Further information and application blanks for any of these summer programs may be obtained from the Director of the Summer Session, Room 3-107, Massachusetts Institute of Technology, Cambridge 39, Mass.

Unique Measuring System Predetermines Picture Quality

Unprecedented mathematical accuracy in predetermining the quality of images any given television or photographic system will produce was reported recently as the result of progress on a unique measuring system which permits for the first time the scientific grading of picture-producing instruments.

The progress was outlined in a technical paper by Otto H. Schade, RCA Tube Department engineer.

Eighteen months ago, Mr. Schade disclosed his system of universal ratings which can be applied to measure with scientific objectivity the quality of all image-producing instruments—camera and projection lenses, television camera and picture tubes, and positive and negative motion-picture film. He now has outlined the use of the system to translate optical properties of images into electrical terms.

The new application is based on the establishment of electro-optical equivalents to permit accurate expression of optical characteristics in mathematical language, he explained. For example, many significant properties of an image depend upon the characteristics of its "star" image (image of a point source of light). The

table of electro-optical equivalents shows the star image of an optical "circuit" to be the counterpart of the impulse response of an electric circuit. Accordingly, the mathematical relations between electric impulse responses, frequency characteristics, and edge transitions can be applied to compute counterpart properties of optical star images.

The importance of the electro-optical equivalents to the television and motion picture industry, Mr. Schade said, is that they can be applied to grade accurately the quality of the elements of any image-producing system. The gradings, in turn, make it possible to predetermine mathematically the quality of the picture which the system is capable of producing.

Conversely, knowing the picture-quality required, equipment designers can apply the electro-optical equivalents to determine the characteristics required by each element of any image-producing system to produce such quality, he said.

To illustrate, Mr. Schade pointed out that the measuring system has been applied to determine the requirements of a theater television system capable of moving-picture quality. Having measured the quality of standard motion pictures, it was possible to specify the characteristics of television camera tube, optical system, projection kinescope, and other elements required for such a theater television system.

This scientific approach points the way to optimum equipment design, he declared. Heretofore, the picture quality of television and photographic systems has been determined visually. The ratings system will enable the motion picture industry, film processors, lens makers, and television tube manufacturers to determine quickly and accurately with electronic instruments the characteristics of basic elements of television and photographic systems and to apply the measurements against mathematical optimums.

Airliners Simulate Lighthouses to Increase Safety in the Air

"Flying lighthouses" are being adopted by commercial air lines in the United States as the latest move in their constant effort to increase aerial safety.

These lighthouses-in-the-sky are the airliners themselves, many of which henceforth will carry a high-intensity rotating beacon mounted high atop the vertical fin of the tail assembly. Greater safety in the air is the expected result.

Light source for the beacon is a $4\frac{1}{2}$-inch-diameter lamp of the sealed-beam type, developed especially for this purpose by the General Electric Company. Company spokesmen said the new lamp will indicate an airplane's presence at greater distances, both day and night, than do present standard lights.

The lamp, which produces a light beam of 50,000 candlepower, nearly 50 per cent greater than that of an automobile headlamp, was developed for United Air Lines and the Civil Aeronautics Administration. At least two air lines now are equipping their fleets, and others are expected to adopt this new safety device.

The light source, mounted in a fixture which rotates the beam horizontally, is visible from all points of the compass. A colored glass dome fitted over the lamp and rotating mechanism produces a deep-red beam. The fixture itself was developed by United Air Lines.

Quicker and easier identification of airliners is provided by a new rotating beacon light, mounted atop the tail assembly. A powerful new sealed-beam lamp developed for the unit by General Electric produces a beam 50 per cent more powerful than that of an automobile headlamp. Inspecting the light are two engineers of the United Air Lines, which developed the marker

The new beacon light is seen as greatly reducing the danger of 2-airplane collisions during darkness or other poor-visibility conditions, and making the visibility and identification of airplanes easier in normal daylight seeing situations.

Colloidal Graphite Used in Atomic Battery

An "atomic battery," a new product of our age, has been developed. This device, possessing far-reaching potentialities, is already perfected to a point where it delivers a small current almost indefinitely. "Aquadag," a dispersion of colloidal graphite in water, is used to form an anodic coating on the positive electrode in the battery cell.

Primarily a metrological tool at this stage of its development, the atomic battery plays an important part in the manufacture of new instruments for precise measurement of radioactivity. It also can be used to measure liquid levels, liquid interfaces, specific gravity, temperature, and pressure (or vacuum). Further possibilities, much different, exist for such functions as measurements of corrosion rates and analyses of alloys and of gases.

Philip E. Ohmart, president and director of research of the Ohmart Corporation, Cincinnati, Ohio, is the inventor of the battery. It was he who evolved a method of utilizing radioactivity in the generation of electric energy. His theory, which makes use of a gas as an electrolyte after ionizing it by exposure to nuclear radiation, was developed during his work as leader of a research group.

It has been found that a cell with electrodes of lead and gold—far apart on the electromotive series—delivered a small current when the air surrounding them was exposed to radiation from as little as 25 millicuries of radium. When the pole connections were reversed, the current likewise reversed its direction. This showed that the electric current being generated in the cell, with a gaseous electrolyte, was a result of radioactivity. To check this theory, an airtight cell was built. As this cell was evacuated, the current dropped steadily. Upon further evacuation, the current fell to zero. (And when a high degree of vacuum was established, a negative current resulted.)

After the initial work with lead and gold as electrodes, Aquadag was found to be more suitable as the positive electrode because graphite is beyond gold on the electromotive series. Other forms of carbon were tested but the highest positive potential for this type of electrode is produced by the colloidal graphite. It is also the most stable. Thus, Aquadag made possible the improved Ohmart cell now in use. This product is also employed for treating surfaces of Ohmart's instruments to eliminate contact-potential current or other stray electricity.

An atomic battery has been built which

Philip E. Ohmart, inventor of the atomic battery, with a cell used for the detection of beta particles. Aquadag is used as an electrode in the cell because it is more electrically positive than gold, which was previously tried

will deliver enough current to run a very small electric motor. Mr. Ohmart does not claim his invention to be a feasible source of power for mankind, but the Ohmart cell does make possible a battery for use where only a trace of current is needed.

ECPD Announces Pamphlet on Careers in Engineering

Engineers' Council for Professional Development (ECPD) has prepared a pamphlet entitled "Engineering—A Creative Profession," to aid in encouraging young people to choose engineering as a career.

The pamphlet discusses the meaning of engineering and the different phases it may take. It also tells what the prospective engineer should study in high school and how he is trained in the engineering colleges. The various branches of engineering are described in detail and the opportunities and fields of work are pointed out.

The pamphlet is available from ECPD, 29 West 39th Street, New York, N. Y., price 25¢ per copy; 20¢ per copy in quantities of 50 or more.

Group Asks Charter to Spur Use of Atom in Industry

A group of leading businessmen, engineers, scientists, and educators interested in the development of industrial uses for atomic energy has reported filing papers of incorporation with the Secretary of State, Albany, N. Y.

The group, to be known as Atomic Industrial Forum, Inc., will not be a lobbying group, according to W. L. Cisler (F '47), spokesman for the group.

Outlined objectives of the forum, said Mr. Cisler, will be

1. To foster and encourage development and utilization of atomic energy in accordance with the best traditions of American democracy and free competitive enterprise.

2. To provide a forum in which individuals and organizations may consult and co-operate in solving problems relating to atomic energy and which concern the nation, industry, or the general public.

3. To promote dissemination, consistent with national security, of knowledge and understanding relating to development of atomic energy.

4. To foster and encourage research and development relating to atomic energy.

There will be two classes of membership with the entire operation financed by dues. Regular members will be those who are lawfully entitled to access to restricted data as defined in the Atomic Energy Act of 1946. This group will have sole voting privileges and membership on the board of directors will be limited to them.

Special memberships will be open to individuals, corporations, associations, partnerships, and trusts which are interested in development of atomic energy.

The forum will maintain present headquarters in the Engineering Societies Building, 29 West 39th Street, New York, N. Y.

Study Indicates Computers Impractical for Meter Reading

Results of a study applying computing machines to watt-hour meter reading and billing are described by J. R. Macintyre and W. C. Israel in a paper on "Watt-Hour Meter Reading and Billing" presented at the AIEE Winter General Meeting in January 1953.

Although results at the present time seemed to show that telemetering and computing systems were impractical in this field, it was hoped that others would give thought to the problem and perhaps arrive at a solution.

The study showed that it is not economically feasible to apply a telemetering system to the meter reading problem, using any existing schemes. Meter telemetering could be made economically feasible only by the invention of new telemetering methods; possibly in conjunction with new metering means adapted to telemetering. At present, the authors did not know of any promising possibilities in that field.

An economic study of a portable bill computer also was undertaken. The bill computer was visualized as a portable device designed to work with punched tabulating card equipment as used in many systems of utility accounting. It would be carried by the meter reader, and would record the meter reading on suitable punched cards, calculate usage charges, and print a bill. It was estimated that savings in billing and accounting would be obtained, although an increase in cost of meter reading time would be expected.

A survey using the portable bill computer showed an increase in cost of meter reading and billing, so further work in this field is not anticipated.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

BERECHNUNG MAGNETISCHER FELDER. (Technische Elektrodynamik, Volume 1.) By Franz Ollendorff. Springer-Verlag, Vienna, 1952. 432 pages, 9¼ by 6¾ inches, bound. $15.70. This book on the calculation of magnetic fields, first of a proposed series of six volumes on "Technical Electrodynamics," is intended both for the designer in the electrical industry and the engineer in the plant laboratory. Dealing chiefly with the mathematical analysis of fields the book also considers graphical methods. Important topics covered include the following: field calculations of synchronous and asynchronous machines; leakage theory of autotransformers; determination of the pulling forces of split-pole systems, gripping plates, and magnetic separators; and qualitative descriptions of certain measuring devices.

CHEMICAL PROCESSING OF WOOD. By Alfred J. Stamm and Elwin E. Harris. Chemical Publishing Company, Inc., 212 Fifth Avenue, New York, N. Y., 1953. 595 pages, 8¾ by 5¾ inches, bound. $12. A comprehensive presentation of information on the chemical utilization of woods, especially of wood residues and inferior species of wood, to produce modified wood products, pulp products and various derived chemicals. Both conventional and new methods are included with emphasis on the more recently developed processes. As introduction to the specialized sections, the first few chapters are devoted to the basic physical and chemical properties of wood. The book constitutes a critical survey of the extensive literature on the subject and presents both the favorable and unfavorable features of each process together with the economic limitations.

DESCRIPTION OF A MAGNETIC DRUM CALCULATOR. (Annals of the Computation Laboratory, Volume XXV.) By the staff of the Computation Laboratory. Harvard University Press, Cambridge Mass., 1952. 318 pages, 10¾ by 8 inches, bound. $8. This volume describes the design and construction of the Mark III Calculator, an electronic digital calculator employing rotating magnetic drums for the storage of numerical and instructional information. It covers the subroutines for the computation of the elementary functions, provides a manual of operation, and gives the detailed coding for the solution of four illustrative problems. The necessary information is given for the maintenance and improvement of the machine as well as for its use in the solution of problems.

ELECTRIC CONTROL SYSTEMS. By Richard W. Jones. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., third edition, 1953. 511 pages, 9½ by 6 inches, bound. $7.75. The primary concern of this book is with control systems for motor drives, with emphasis on the utilization of electric power. Aspects of control in generation and transmission are not considered. The author concentrates on basic types, emphasizing the functional aspects of control, rather than attempting a complete treatment of all control elements and systems. Most of the discussion is devoted to systems having no feedback, but the essential features of feedback systems are introduced. A list of references accompanies each chapter.

THE ELECTRICAL MANUFACTURERS, 1875–1900. By Harold C. Passer. Harvard University Press, Cambridge, Mass., 1953. 412 pages, 9½ by 6½ inches, bound. $6. This book is a study of the origins and developments of the electrical manufacturing industry and of the men, called engineer-entrepreneurs, who were responsible for them: Brush, Edison, Westinghouse, Sprague, Thomson, and so forth. The book is organized in three parts: arc lighting, incandescent lighting, and electric power within which are considered four major analytical problems—entrepreneurship, technical change, competition, and economic growth. Neither a technical history nor a conventional economic history, the book's emphasis is on the forces that brought major changes in the industry and the manner in which technological innovations became effective in business. A summary chapter includes suggestions for public policy made on the basis of the study.

ELECTRODYNAMICS. (Lectures on Theoretical Physics, Volume III.) By Arnold Sommerfeld. Translated by Edward G. Ramberg. Academic Press, Inc., 125 East 23d Street, New York 10, N. Y., 1952. 372 pages, 9¼ by 6½ inches, bound. $6.80. In Part I the author discusses general fundamentals and the basic principles of Maxwell's electrodynamics. In Part II the several classes of phenomena, in static, stationary, quasistationary, and rapidly variable fields, are derived from Maxwell's equations. Part III, on the theory of relativity and electron theory, is limited to the special theory of relativity and the theory of the individual electron. The electrodynamics of moving media is developed in Part IV. Waveguides and a number of other special topics are considered in their proper place in the treatise, which closes with a considerable section of illustrative problems.

TRANSMISSION TELEPHONIQUE. Theorie des Lignes. By R. Croze and L. Simon. Editions Eyrolles, Paris, France, 1952. 568 pages, 9¾ by 6½ inches, paper. Frs. 2,960. A textbook covering both theory and practical application. Part I deals with the analysis of transmission-line characteristics, covering primary and secondary parameters, distortions in transmission, loaded lines, and other important topics. Part II provides an extensive discussion of the problem of crosstalk.

SYMPOSIUM ON FLAME PHOTOMETRY. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. (Special Technical Publication Number 116) 1952. 120 pages, 9 by 6 inches, paper. $2. The 11 papers included in this symposium present a brief review of flame photometry, describe several currently used photometers and procedures, discuss certain special problems, and give detailed methods for some specific determinations, such as tetraethyl lead in gasoline. References to other material accompany most of the papers.

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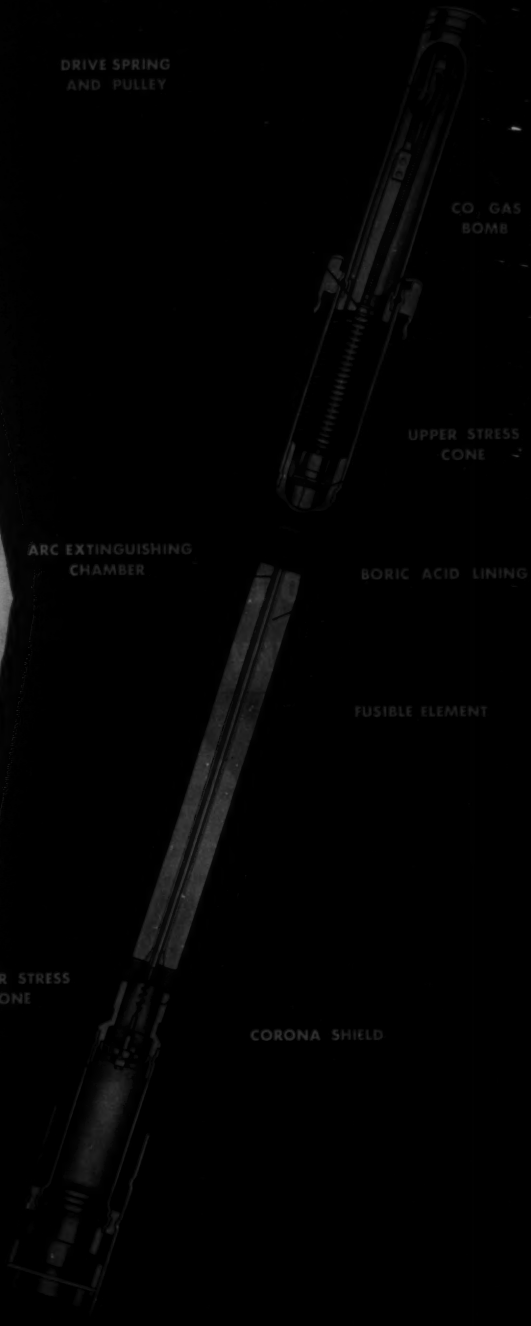

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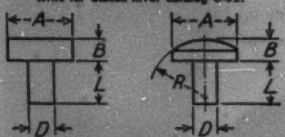

A = head diameter D = shank diameter
B = head thickness L = shank length
R = radius of face

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INDUSTRIAL NOTES ....

General Electric Notes. A new "soundproof" building for noise-testing transformers at a lower cost was announced by the Power Transformer Department in Schenectady, N. Y. Test results are expected to point the way to reducing vibrations in even the largest units. The sound test building, which will be ready for use early in 1954, was designed by Charles T. Main, Inc., Boston, Mass., and is being constructed by the Gilbane Building Company, Providence, R. I.

The Wiring Device Department at Bridgeport, Conn., and the Monowatt Department at Providence have been consolidated into a new department to be known as the G-E Wiring Device Department with headquarters at Providence. Abe F. Warren has been appointed general manager and Arville W. Gilmore assistant general manager. Both General Electric and Monowatt brand lines will be retained and manufacturing operations will be continued at present locations.

Dr. Walter R. Hibbard, Jr., has been appointed manager of the newly established alloy studies section in the Research Laboratory's Metallurgy Research Department in Schenectady.

Gordon R. Rahmes of Schenectady has been appointed a district sales manager for replacement tubes, and Gordon E. Burns, field sales manager of replacement sales for the Tube Department. Mr. Rahmes will make his headquarters at the Tube Department's eastern regional sales offices at Clifton, N. J.

The appointment of Sidney G. Stevens as manager of marketing for the specialty refrigeration department in Louisville, Ky., was announced.

Frank B. Gray was named manager of sales for air conditioners in Louisville replacing R. Dail Moore who recently was transferred to Schenectady, N. Y.

New RCA Appointment. Paul Bergquist, well-known broadcast consultant, has been appointed field sales representative for RCA broadcast equipment in Maryland and Virginia. From October 1946, until he received this appointment, he was a partner in the consulting firm of Gillett and Bergquist. Mr. Bergquist will have his headquarters in RCA Victor's Washington, D. C., office at 1625 K Street, N. W.

New Factory Branch. In order to expand its West Coast service, the Automatic Switch Company (ASCO) of Orange, N. J., will open a factory branch at 923 East Third Street, Los Angeles 13, Calif. This branch will stock a wide variety of solenoid valves and electromagnetic control, and will function as the ASCO West Coast service center.

New Appointment. General Cable Corporation has appointed William B. Bisker as advertising and sales promotion manager. Previously he was sales promotion manager for Lever Brothers. Before that he was with the du Pont Company in their Plastics Division advertising and sales promotion unit.

Raytheon Notes. Raytheon Television and Radio Corporation, formerly Belmont Radio Corporation, of Chicago, Ill., and Owlwein, Iowa, a wholly owned subsidiary of Raytheon Manufacturing Company, Waltham, Mass., will be merged into the parent company as of the close of business May 31, 1953. The new fiscal year begins on June 1, 1953, and the merger will be made to coincide with this.

The appointment of Henry F. Argento as vice-president and general manager of Raytheon Television and Radio Corporation, Chicago, a subsidiary of Raytheon Manufacturing Company, Waltham, was announced.

Cope Appointment. William S. Taylor recently was added to the sales engineering staff of T. J. Cope, Inc., Philadelphia, Pa. The company manufactures Cope Cable Trough for electrical cable installations and Instrof for installing instrument tubing. Mr. Taylor will make his headquarters in Philadelphia.

Territorial Changes. Holophane Company, Inc., announces the following changes in territorial coverage, effective April 1: Daniel R. Donnelly, New York district manager, servicing the greater metropolitan area in co-operation with Edward L. Gluck and Willard L. Warren; Robert W. Stanley, district manager in Connecticut and western Massachusetts, with headquarters in Hartford, Conn.; and Adriaan Van Oss, district manager in Michigan, with headquarters in Detroit.

Distribution Manager Named. Appointment of Donald A. Stewart as distribution manager for the Television Transmitter Division of Allen B. Du Mont Laboratories Inc., has been announced.

Lenkurt Electric Names Engineering Representative. Robert E. Graham has been named engineering representative in the Sales Engineering Division of Lenkurt Electric Company, San Carlos, Calif., manufacturers of telephone and telegraph carrier and radio equipment.

Production Starts in New IRC Plant. On March 13, 1953, the International Resistance Company, Philadelphia, Pa., started transferral operations to move a portion of its production facilities to a recently built, modern plant situated on a 66-acre site in Asheville, N. C. Production is already underway in the spacious $200,000 plant of the various types of volume controls used in radios, television sets, phonographs, testing equipment, military equipment, and numerous other devices.

Change of Address. F. M. Ballou, Manufacturer's Representative for the

(*Continued on page 22A*)

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5000-7000 mc. frequency range means high-gain, interference free signals. Philco's "Carrier Control"—the exclusive feed-back principle—minimizes carrier distortion. And all Philco systems are designed to provide a thirty-decibel safety margin to combat most severe fading conditions. Only Philco microwave gives sure communications and complete control.

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If you haven't met Bob McCoy—chief Design Engineer at Locke . . . you probably know about some of his achievements. Bob gets around, plenty, helping Locke customers lick all kinds of tough insulator problems. His 28-year experience came in mighty handy in this case of AG & ESC which Bob describes for you here. Bob's *our* man . . . but remember, when you've got a "toughie," he's *yours* for the asking!

1

New Suspension Clamp Developed — To support the large, hollow copper conductors used on the TIDD 500 kv experimental line, Locke designed and furnished a radically new articulated suspension clamp, much shorter and lighter than conventional clamps. Overall length of the new Locke clamp is 18 inches long, compared with the 33 inch overall length of a conventional clamp.

2

New Corona Shield Developed — To lick the corona problem on the TIDD 500 kv transmission line experiment Locke developed a new concept in corona shields. These shields graded the insulator strings and suppressed corona on the lower, highly stressed units. They also developed the suspension clamp, thus removing it from the high voltage field and suppressing corona on any part of the clamp itself.

3

Valuable New Data was revealed by extensive flashover tests conducted in the Fred M. Locke High Voltage Laboratory on varied suspension strings. These flashover tests were made with the insulators supported in a specially developed test rig to simulate true electrical conditions. As a result, important data was developed which helped establish the proper number of insulators to use per string.

"When a new high voltage system was planned by the American Gas & Electric Service Corporation, Locke was given an opportunity to participate in the early development stage . . . and follow through to the conclusion," explains Bob.

"Our first job was to cooperate in the company's TIDD 500 kv transmission research project. At this voltage, one of the big problems was corona suppression. The pictures show the special products Locke developed to help the company lick this problem.

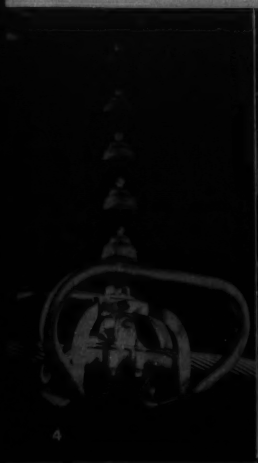
"After the experimental TIDD tests were completed, it was decided that 330 kv best suited the system's requirements. Naturally, this called for a re-study of the whole problem with emphasis on reducing size and cost, as well as how to make hot line maintenance work easier and safer. Here again the pictures show you what Locke did to help AG&E lick the problem.

"In my opinion," observes Bob, "this is an outstanding case of how Locke can . . . and does . . . provide unusual and often most unexpected services for its customers. And remember—all of these 'service extras' are included in the regular price you pay for Locke insulators.

"So whenever you run into a problem of insulator design or application," urges Bob, "bring it to Locke. Your problem will be solved with the aid of one of the world's finest high voltage and mechanical research and development laboratories . . . staffed by engineers who are experts in the design and operation of insulators, as well as associated fittings."

LOCKE DEPARTMENT
GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

Vol. 72
1953



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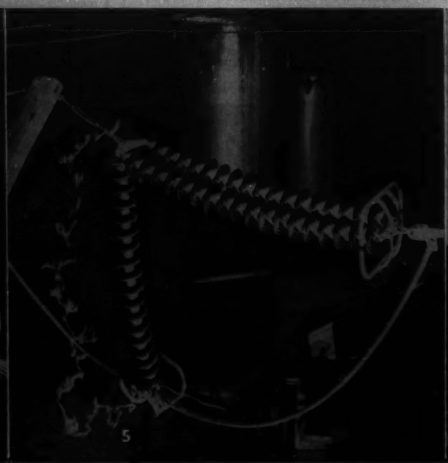


5

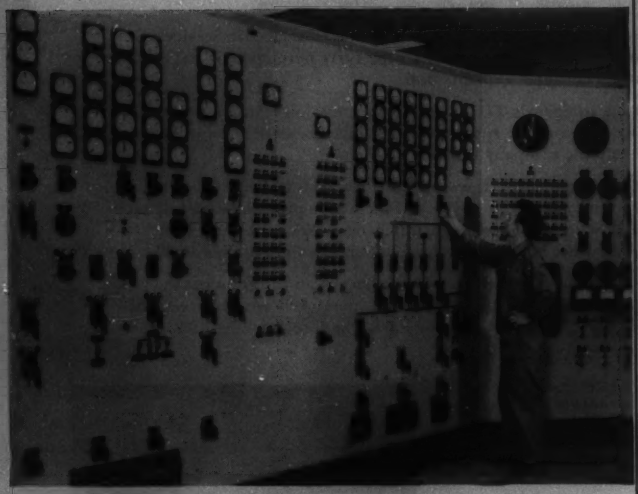
6

Hot Line Work Made Easier and Safer—At the conclusion of the TIDD tests, it was decided that 330 kv best suited the system's requirements. The entire problem was re-studied with an eye toward reducing size and cost and to make hot line maintenance easier and safer. The light weight, aluminum corona shields which can be removed and replaced on the suspension strings by removing only one self-locking nut was Locke's answer to the hot line maintenance problem.

Shield Removal Made Easier—In the case of the dead-end strings, Locke developed shields which can be removed and replaced by removing only two self-locking nuts. Instead of the shield being made in two halves, a one-piece shield was developed having an opening on the under side to clear the jumper loop. This one-piece shield was supported by two supports from the upper side with which bolts for attaching to the strain yoke were made integral.

Lines Now Operating—Today the first of these extra high voltage lines is in operation at 138 kv on the system of the Appalachian Electric Power Company. Half of this line is Locke equipped. Based on Locke laboratory tests made on the Tidd Line, the company has complete confidence that the lines will perform as expected when the new 330 kv service is made available. Locke welcomes unusual opportunities like this to assist its customers.

Easy-reading K-24 instruments



Give you more freedom in switchboard design

Sometimes the instruments on your switchboards can have significant effects on the overall design. The power station above is a good example of creative switchboard design with the right instruments.

The Westinghouse Full-View K-24 instruments on the board are exceptionally readable—even from sharp angles. Thus the designer was able to stack them up high on the board. Old-style instruments aren't easily read from this angle so they would have been set lower and spread out—resulting in a longer, less compact board.

You can see the results of this superior readability. The operator can see many more instruments from where he stands. This makes him more efficient and he can act faster when action is needed. And because the whole unit takes up less space and material, the overall cost was lower.

Westinghouse supplies a complete, co-ordinated line of electrical measuring instruments for every switchboard application. Write now for booklet, B-4695, "Getting A Full Measure". Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania.

J-40427

You can read the K-24 accurately under any lighting conditions and from very wide angles—up to 50°. Shadows, glare and parallax are practically nonexistent. It is a triumph of optical engineering.

YOU CAN BE SURE...IF IT'S
Westinghouse

EVERYTHING YOU NEED IN METERS AND INSTRUMENTS

(*Continued from page 18A*)

Nelson Electric Manufacturing Company, has opened a branch office at 300 South Broadway, Room 512-A, Camden 3, N. J. J. Boylston Campbell, who has been with F. M. Ballou for the past year, has been appointed to this office.

NEW PRODUCTS . . .

Radio Tube Finds New Uses. Important cost savings in the design and operation of ultrahigh-frequency and very-high-frequency television transmitters result from the application of a potent, versatile beam power amplifier tube which was introduced last year for use primarily in mobile radio and amateur communications, the Tube Department of RCA Victor reported. Developed by RCA engineers, the tube (*RCA-6146*) is finding a wide range of applications in new ultrahigh-frequency and very-high-frequency television transmitters being produced by several equipment manufacturers. It is being used in radio-frequency amplifier circuits, tripler circuits, and video amplifier circuits. Operating economies stem chiefly from this tube's efficient production of power at the higher frequencies, its low driving-power requirements, and its small size. In video use, it can handle high plate current without drawing grid current. This characteristic leads to a simplification of the video amplifier, since it does not have to be designed to provide grid current for the modulator stage. Engineered to operate efficiently at relatively low plate voltage, the company reported, the "mighty midget" tube has also found widespread amateur application on all bands, including the 2-meter band, during the 12 months it has been on the market.

Dual-Rated Transformer. Production of a new dual-rated dry-type heatproof insulated transformer that takes overloads for far longer periods has been announced by Marcus Transformer Company, Hillside, N. J. The transformer earns the double rating as a result of blowers mounted in the housing, and a thermostat located in the coils. One rating covers its operation without the blowers functioning, at which time the transformer is naturally cooled. When heat reaches a certain level the thermostat activates the blowers, and this provides scientific forced-air cooling that automatically increases the transformer's rating by 33⅓ per cent. Baffles in the housing direct the moving air over and through the coils. Air vents are located front and rear, top and bottom. Available in ratings from 100 to 3,000 kva in voltages to 15,000 volts.

New General-Purpose Relays. A complete new line of general-purpose relays, featuring longer life and greater flexibility of application, has been announced by the

(*Continued on page 28A*)

CONTOURED
BRUSHES for

because . . .
HELWIG CARBON
BRUSHES are "Custom-Bilt"
for instant installation . . . .

Cut brush replacement and motor repair to a minimum with Precision-made Helwig brushes—They fit your commutator and rings exactly.

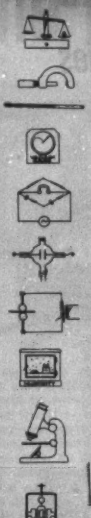
Quality Helwig brushes eliminate uneven wear, reduce sparking and improve brush life.

Write for catalog No. 95 for complete details on types of brushes and grade recommendations for every use.

HELWIG CO. CARBON PRODUCTS
2547 N. 30th St., Milwaukee 10, Wisconsin

HELWIG SPEER

Another Step in
Getting to the bottom of things



At John E. Fast and Co., the watchdogs of quality are on the job twenty-four hours a day, in every stage of capacitor production. Recording controls indicate the smallest variations in heat, humidity, pressure and vacuum at each process point. Every precaution is taken to assure that environmental conditions are held at precise levels specified by our engineers.

The air in our winding rooms, for example, is continuously filtered so that no foreign particles may settle upon the windings themselves and contribute to ultimate failures. Similarly, capacitors are assembled, after vacuum impregnation, in clean rooms, where relative humidity is controlled at all times. These safeguards against inclusion of extraneous matter or moisture have resulted in increasingly satisfactory life and allied performances in Fast capacitors.

Supplementing this automatic vigilance is a completely equipped quality-control organization which functions at every process-stage from incoming inspection to final testing. At points where statistical control is applicable, our inspectors utilize techniques which comply with or exceed specifications laid down by the Armed Services Procurement Branches.

At final testing stations each production lot is given 100% test and inspection. Our belief is that a single failure out of a thousand may satisfy any sampling requirement, but it may be extremely costly to the consumer. Our investment in precision testing devices and extensive laboratory equipments is great, but its worth is reflected in our national reputation as producers of quality components.

Comprehensive reports are maintained by inspection centers located at strategic production points. These reports are summarized weekly, and it is quite significant to note that both the President of the Company and the Vice-President and Chief Engineer meet each Saturday morning with supervisors, engineers and military representatives to discuss the various problems indicated by process averages, and yield analyses for each production department.

In these days when every hour taken from the production job is spared grudgingly, we still take these hours every week to analyze and combat any threat to quality performance. Increasingly rigid specifications for dimensional and operational characteristics have shown very clearly that control of quality can be achieved and maintained only by rigorous application of all the techniques and tools we are employing.

No greater assurance of excellence may be given than that which has established our reputation. Our fixed objective will always be to maintain that reputation.

AVAILABLE LITERATURE:
Tubular Capacitors in paper tubes, 85° or 85°C rating SEB. I, CATALOG 15
Polystyrene Capacitors in paper tubes or metallic containers SEB. III, CATALOG 16
Hermetically-sealed Tubular Capacitors SEB. VI, CATALOG 25
Subminiature Capacitors: Special Bulletin.
Jan 5-21 Approved Capacitors: refer to Jan 5-26, "Specifications"
Power-Factor Correction Capacitors SEBS. I, II, III, IV, CATALOG 27

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...FOR EVERY REQUIREMENT IN THE ELECTRICAL FIELD

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PHILADELPHIA 25, PENNSYLVANIA

Report on
GUIDING PRINCIPLES for DIELECTRIC TESTS
(Published for comment and criticism)

The service record of electric equipment depends largely upon the performance of its insulation, and it has long been the practice to test new insulation at a voltage appreciably greater than its rated operating voltage. Dielectric test voltages should be chosen to result in good operating performance and satisfactory life. The purpose of this report (AIEE No. 51, September, 1949) therefore, is (1) to present a survey of the overvoltages encountered in service, (2) to review existing test values and practices in present standards, (3) to propose guiding principles for the selection of dielectric test values, and (4) to investigate other types of testing to determine their latent usefulness and the desirability of standardization.

+ + +

Proposed Standard for
AUTOMATIC CIRCUIT RECLOSERS for DISTRIBUTION SYSTEMS
(Proposed for one year trial use)

This standard (AIEE No. 50, September, 1949) applies to all single or multipole a-c automatic circuit reclosers rated from 1,500 to 15,000 volts. The work of preparing this standard was carried out by the Working Group on Automatic Circuit Reclosers under the Circuit Breaker Subcommittee of the AIEE Committee on Switchgear.

There is no charge for these publications. Orders should be sent to:
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
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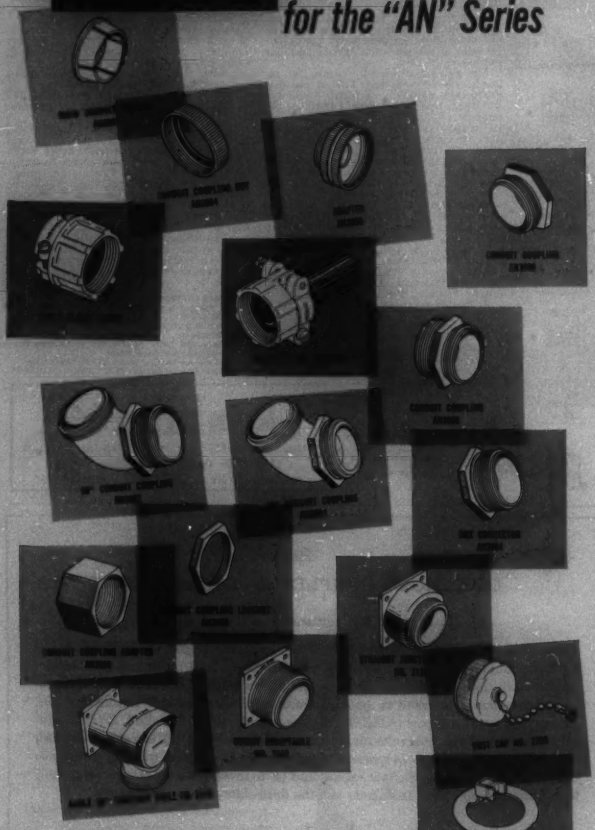
6-53

CANNON PLUG ACCESSORIES

for the "AN" Series



Here is the answer to a frequent question we receive from people everywhere. Yes, Cannon *does* make a complete line of accessories to be used in conjunction with the AN Series of connectors. Complete engineering data on each of these is given in the Cannon AN Bulletin, available on request.

CANNON ELECTRIC

Since 1915

Factories in Los Angeles, Toronto, New Haven, Benton Harbor. Representatives in principal cities. Address inquiries to Cannon Electric Company, Dept. F-117, P. O. Box 75, Lincoln Heights Station, Los Angeles 31, California.

LIGHTNING REFERENCE BIBLIOGRAPHY 1936-1949

Prepared by the AIEE Lightning and Insulator Subcommittee, this bibliography, S-37, contains 754 separate references on lightning and related topics published from January 1, 1936, to December 31, 1949, in most of the better known English, French, and German journals on electrical engineering or physics.

For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

Available from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York, N. Y.

6-53

MEASUREMENT of FIELD INTENSITY ABOVE 300 MC

from R-F Industrial, Scientific, and Medical Equipments No. 950

This recommended practice gives information on methods of measurement, antenna design, and equipments used in making field intensity measurements after study of the problems resulting from the FCC rules relating to the operation of this type of equipment. Price: $0.80; 50 per cent discount to members of the AIEE.

Address: Order Department
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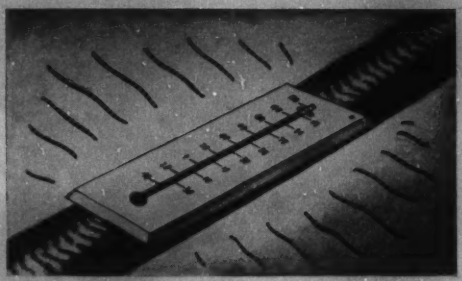
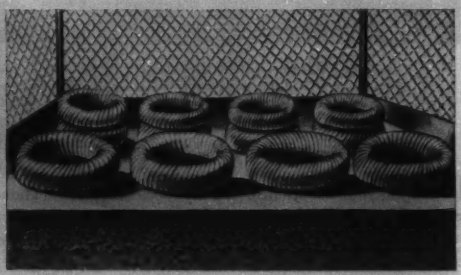
6-53

How to prolong the life of wire and cable by proper storage



1 **Protect cables from the weather.** Moisture is especially injurious to fibrous coverings. When stored out-of-doors, if they become wet and then freeze, they will be weakened and the saturant will flake off. In humid weather, mold growth is accelerated, weakening the covering and making it easier to damage the cable during installation. (Rubber and thermoplastic insulated and jacketed cables may be stored under moderately humid conditions.) The larger sizes of fibrous covered and rubber jacketed cables and all lead-sheathed rubber insulated cables must be stored on reels which must be properly lagged—or the cable must be otherwise suitably protected against mechanical damage. Reels can be stored out-of-doors if the cable is protected against sun and weather, and the ends are properly sealed.

2 **Don't expose wires and cables to extremes of temperature.** Chemical reactions occur at a higher rate at high temperatures than low. The greatest deterioration of low-voltage cables is due to chemical changes, oxidation or internal changes in the compound itself. Never store reels in the boiler room unless you use a fan to blow hot air away from the wires and cables. It's best to store cables at room temperatures indoors out of direct sunlight. Rubber insulated cables may be stored and handled without damage at the lowest temperatures ordinarily encountered, but thermoplastic synthetic insulated cables should not be handled at temperatures below −10 C. (14 F.)



3 **Reels should be kept off the ground,** so that moisture will not harm the cables, reel flanges and lagging. Sound reels are easier to handle and there is less chance of injury to the cable as it is removed from the reel.

4 **Coils should be stored one layer deep on the floor or shelves,** with the axis either horizontal or vertical. To save space, they may be stacked, but not more than 5 coils in height—otherwise there is harmful pressure on the insulation. Don't remove brown paper or box that protects against dust and light until used.

5 **Rubber insulated fibrous covered, rubber jacketed or lead-sheathed cables in storage** should never be bent to a diameter less than I.P.C.E.A. recommended diameters. Never let coils or reels drop more than a few inches. Always roll a reel in the direction indicated by the arrow on the flange. When rolling an unlagged reel, put planks under the flanges to avoid pressure on the cable. Coils, reels and spools should always be rotated when wire and cable is removed to avoid twisting the cable.

FREE REPRINTS OF THIS PAGE ARE AVAILABLE. WRITE TO ADDRESS BELOW.

UNITED STATES RUBBER COMPANY

U.S. RUBBER
SERVING THROUGH SCIENCE

Electrical Wire and Cable Department

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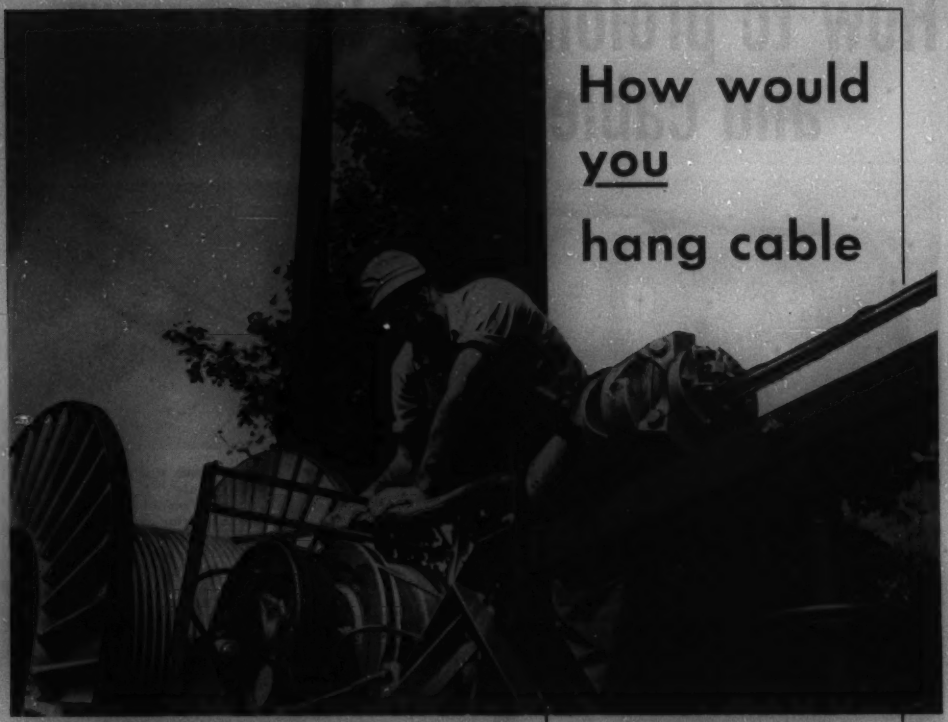


How would you hang cable ...by the mile?

Cable lasher appears to right of workman. As the cable and supporting strand feed through, the machine rotates, binding them together with steel lashing wire. Meanwhile, a winch hauls the lashed cable into position.

It is a job your telephone company faces every day. Thousands of miles of cable go up each year—all secured to steel strand running from pole to pole. The best way to secure cable is to *lash* it to the strand with a spiral binding of wire.

One way to do this is to raise cable and strand separately, then lash them together by a rotating machine pulled along by workmen on the ground. This produces a strong, tight support for the cable. But each pole has to be climbed as many as four times. So Bell Laboratories engineers devised an easier way.

Now, lashing can be done *on the ground* so that cable, strand and lashing wire may be pulled into position as a complete assembly. Usually workmen need make only two trips up each pole.

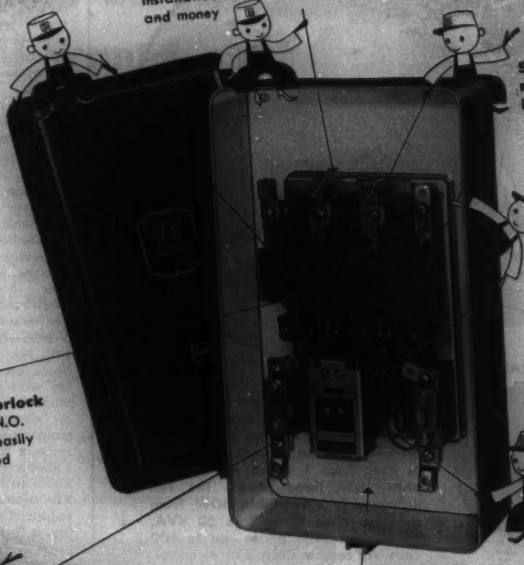
For telephone users, the new way means that cable can be installed faster, while costs are kept down. It shows again how work at Bell Telephone Laboratories improves each part of your telephone system.

Bell Telephone Laboratories

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN MECHANICAL ENGINEERING

NEW Square D Size 4 Starter

Feature-packed!



"Hook-on" base design saves installation time and money

Special sintered metal contacts last longer

High arc-interrupting capacity with "magnetic yoke" arc chamber

Coil and contacts removable from front **without disturbing power wiring**

Up to 8 interlock circuits (4 N.O. and 4 N.C.) easily front-mounted

Permanent air-gap lengthens magnet life

New coil holder simplifies coil change

All parts front-mounted for easy service and maintenance

The highest degree of accessibility, flexibility and compactness—with no sacrifice of performance and long life. That's Square D balanced design—and you'll find it in every size Square D starter.

"Off-the-Shelf" Parts Kits, another Square D convenience feature, make normal maintenance easier than ever. Each kit contains parts to replace all load contacts and finger springs. Electrical interlocks also available in kit form.

Write for Bulletin 8536, Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

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THREE PHASE INSTALLATION

• ECONOMICAL
• COMPACT • EFFICIENT

1 to 3,000 KVA up to 15,000 Volts to meet Individual Requirements
- DISTRIBUTION
- GENERAL PURPOSE
- UNIT SUBSTATION
- PHASE CHANGING
- ELECTRIC FURNACE
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- WELDING
- MOTOR STARTING
- SPECIAL

Representatives in Principal Cities

New MARCUS "Type C" general purpose lighting transformers, for installation either indoors or outdoors, are available for immediate delivery in sizes from 1 to 15 KVA, single phase and three phase. The full lighting line is available NOW, from stock, in sizes from 1 to 50 KVA, single and three phase, up to 600 volts. All contain Class B hi-dielectric, hi-heat magnet wire insulated with DuPont's miracle "Mylar" polyester film with at least ten times the puncture strength of standard magnet wire.

New MARCUS "Type C" indoor-outdoor lighting transformers are constructed with electrically welded sheet steel case. Scientifically placed vents provide completely weather-proof ventilation. Self-contained wiring compartment means faster-than-ever installation.

Write for price list

MTC

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MARCUS
TRANSFORMER CO., Inc.
HILLSIDE 5, NEW JERSEY

ONE OF THE WORLD'S LARGEST MANUFACTURERS OF DRY TYPE TRANSFORMERS EXCLUSIVELY

(*Continued from page 22A*)

General Electric Company's Control Department. Operating life of the new relays has been greatly extended by use of a braided shunt and repositioning of the shunt to reduce tension and wear. Use of the standardized open-form relays with conversion kits, provides units with greater utility and permits reduction in inventory. Conversion units are available for metal and compound base backmounting, base receptacle, relay jack-plug applications, and explosionproof enclosures for dust-tight and Class *1*, Group *D* service. The new relays, designated as *CR2790-E*, are rated from 6 to 300 volts; 60, 50, and 25 cycles plus direct current; and 10-ampere continuous-contact rating. Contact arrangements include double-pole single-throw, double-pole double-throw, and single-throw double-break. The relays may be used as starters for small a-c motors where motors have sufficient overload protection. They also are especially suitable for electronic equipment and air conditioners, where small space and long relay life are major factors.

Precision Wirewound Resistors. New "*G*" type precision resistors developed by the Shallcross Manufacturing Company, Collingdale, Pa., utilize the heat-resistant properties of fiberglass insulated wire to increase wattage ratings 5 to 10 times over those of commercial precision wirewounds of the same dimensions. For example, the new Shallcross Type *G-196E* will dissipate 8 watts in comparison with the 1-watt rating of the standard Shallcross Type *196* resistor. After winding with the special glass-insulated low-temperature-coefficient wire, the resistors are silicone-impregnated for stable high-temperature operation. This permits "*G*" resistors to be conservatively rated for a 150-degree-centigrade temperature rise above an ambient of 25 degrees centigrade. The resistors are particularly useful in industrial and military equipment operating at high temperatures and for applications requiring noninductive precision power resistors. They are available in all standard bobbin sizes and with wattage ratings from 1 to 20 watts. Further details are available on letterhead request to the manufacturer.

"Ken-Seal" Molded Transformers. A new line of molded transformers marketed under the name "Ken-Seal" has been announced by Kenyon Transformer Company of 840 Barry Street, New York, N. Y. They intend to supply the demand for units of exceptionally light weight, small size, and low cost without any sacrifice in hermetic sealing or other efficiency. Molding process was chosen in preference to dipping or encapsulation because it accomplishes this and in addition produces a product which is uniform and controllable to definite dimensions.

New Generator. The Hewlett-Packard Model *618B* Signal Generator is designed

(*Continued on page 34A*)

What kind of wire do YOU want?

You want manufacturers wire to be uniform in grade, strength and analysis . . . free from harmful imperfections . . . meeting specifications exactly. And that's the kind of wire we've been turning out for over a hundred years. Today we can offer you over 400 different types of American Manufacturers Wire, of every size, shape, finish, and metallurgical characteristic . . . and of *consistently* high quality. All this helps to simplify your fabrication job.

Here's another way we can help you. Our staff of trained metallurgists and engineers know wire-application problems inside-out. They've assisted thousands of manufacturers in finding the most suitable wire for a specific job . . . in cutting costs and improving products. And these men are at your service, ready to go to work on your problems too.

If you want a type of wire that we don't regularly produce, you can depend on our modern plant facilities to draw a special wire that will fit your needs exactly. Call our nearest sales office for further information.

If you make it of wire... make it of the best!

U·S·S AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

USS

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO

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UNITED STATES STEEL

As a Direct-Reading Instrument *The extreme sensitivity of the d-c amplifier is utilized to check plasticizer insulation resistance values in the megamegohm range.*

As a Recorder Preamplifier *The rack-mounted amplifier above is being used to increase the sensitivity of a recorder in running special tests of switches.*

As a Null Detector *The d-c Amplifier is being used above for factory checking and calibration of instruments.*

L&N Low Level d-c Amplifiers are

Triple Purpose... for Triple Service

● In response to the constant demand for versatility in precision instruments, these d-c Indicating Amplifiers combine the functions of three useful instruments in one:

1. A Direct-Reading Instrument that is always ready to use . . . never any readjusting of zero, either initially or during a series of readings. Simply select the range in which you want to work by turning scale-multiplier knob.

2. A Recorder Preamplifier — Values measured by Stabilized d-c Amplifiers can be recorded directly on Speedomax recorders.

3. A Null Detector more sensitive than most reflecting galvanometers, yet with full scale response time of only 2 to 3 seconds. These instruments are unaffected by vibration; leveling is not necessary. At the turn of a range knob, a wide choice of sensitivities can be obtained without external shunts. A non-linear response characteristic is also available for easy balancing.

These amplifiers are suitable for handling low level measurements with thermocouples, strain gages, bolometers—bridge and potentiometer circuits—ionization, leakage and phototube currents—almost any measurement of extremely small direct current or voltage.

Self-contained, the unit can either be used "as is" or removed from case and mounted on a 19" relay rack.

For details, including complete specifications, send for Folder EM9-51(1). Write our nearest office, or 4962 Stenton Ave., Phila. 44, Penna.

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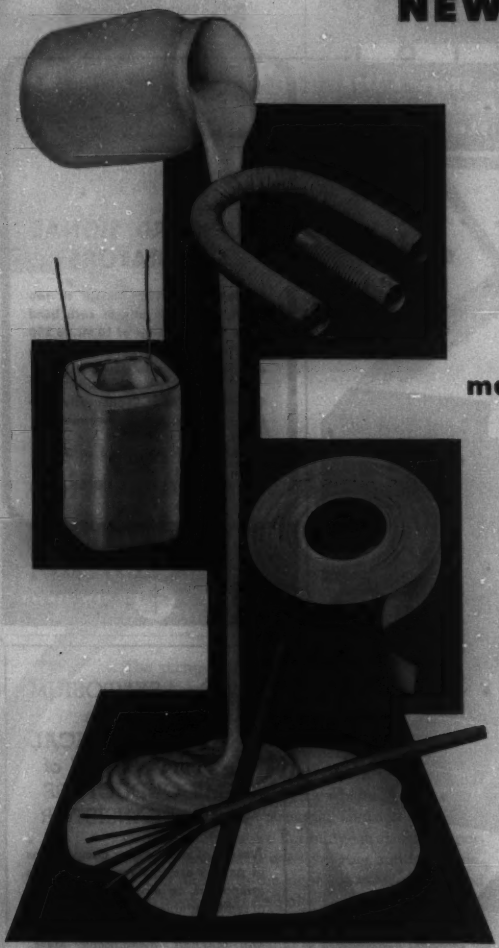

SE-100 COMBINES

- **Outstanding heat resistance**
- **Outstanding electrical properties**
- **Outstanding physical properties**
- **Ease of application**

You can now extend equipment life and minimize insulation failures by specifying General Electric's new silicone rubber compound, SE-100.

SE-100 may be coated on glass or organic fabrics for service at high or low temperatures or where resistance to weather, ozone, corona or chemicals is required. In addition, SE-100 is available as a dispersion (SE-100S) and may be used to encapsulate coils and components for electrical insulating purposes.

SUGGESTED USES

Electrical: Cloth, tape and sleeving; coating for glass-served wire; encapsulating coatings.

Mechanical: Ducts and tubing; gaskets and seals; diaphragms.

HERE'S PROOF!

Typical properties of glass cloth coated with SE-100:

Dielectric strength, volts/mil	1200-1400
Power factor, 60 cycles	
85 F	0.0110
212 F	0.0072
Tensile strength, lbs./in. width	150
% Moisture absorption, 96 hrs.	0.11
Serviceable from	—76 to 480 F

G-E silicones fit in your future

GENERAL ELECTRIC

CLIP AND MAIL TODAY!

General Electric Company
Section 352-3B
Waterford, New York

Please send me product data on SE-100, list of fabricators, and a free copy of *G-E Silicones for Industry*.

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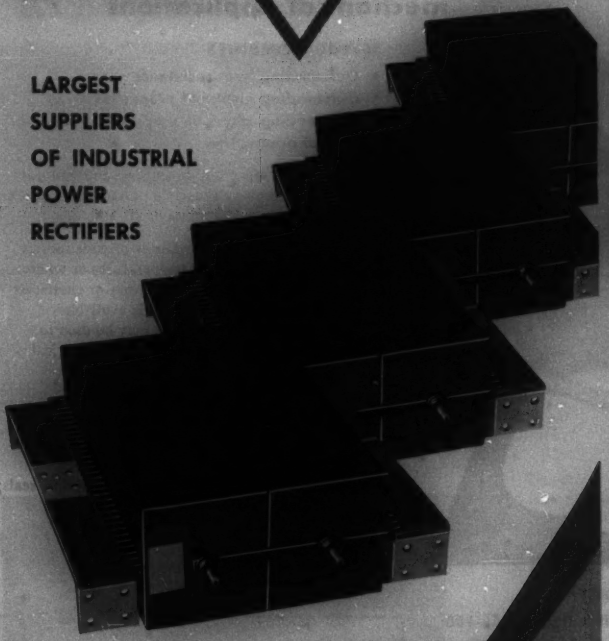

Selenium Rectifiers

Measurements Corporation
MODEL 78

STANDARD SIGNAL GENERATORS

FREQUENCY RANGE: Choice of two bands; frequency ratio of each band 1.8 to 1 within range of 10 Mc. to 250 Mc. Special single band instruments also available up to 420 Mc.

OUTPUT VOLTAGE: Continuously variable from 1 to 100,000 microvolts.

MODULATION: AM, fixed at 30%.

POWER SUPPLY: 117 v., 50/60 cycles.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

SYMPOSIUM on ELECTRICAL PROPERTIES of SEMICONDUCTORS and the TRANSISTOR

A series of four articles, compilations of papers originally presented at a symposium on electrical properties of semiconductors and the transistor, held during the AIEE Summer General Meeting, Swampscott, Mass., June 1949. Sponsored by the Subcommittee on Electrical Properties of Solids and Liquids of the AIEE Committee on Basic Sciences.

It is hoped that this pamphlet (S-36, January 1950) will prove useful not only to the practicing engineer and teacher, but also to engineering students as an introduction to this field of electrical engineering.

Price is $0.50 ($0.25 to AIEE members.) Send orders to: Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York 18, N. Y.

6-53

looking into the future of

BAKELITE POLYETHYLENE

TRADE-MARK

wire covering

The picture above shows samples of BAKELITE Polyethylene being subjected to intense sunlight, day-night effects, and rain — years of exposure crammed into hours — showing evidence of the long-term service to be expected from this great advance in wire and cable constructions.

After this treatment, they will be tested for such features as tensile strength, abrasion resistance, and low temperature flexibility—properties important to their use as wire covering and insulation.

The picture to the right shows wires, covered with black BAKELITE Polyethylene, that have been exposed for years to actual outdoor weathering. There has been no sign of cracking or crazing.

This is just one series of tests made on BAKELITE Polyethylene to maintain quality and to prove its durability. This superior wire covering resists chemicals, oil, water immersion, abrasion. The approved black compound stays flexible down to —70 deg. C., resists deformation up to 90 deg. C. It meets ASA suggested specifications (second draft: July 20, 1952) for weather-resistant wire and cable.

BAKELITE Polyethylene, extruded onto wire, won't festoon. It provides a thin, smooth-surfaced covering that speeds stripping and splicing. Its low specific gravity, only 0.92, means lighter weight—easier stringing.

Kabelitems #48 gives detailed information on BAKELITE Polyethylene. For your free copy, write Dept. QB-66.

OUTSTANDING ELECTRICAL PROPERTIES for signal systems and service drop, wet or dry — at 50 megacycles and 25 deg. C., power factor is only 0.0005; dielectric constant only 2.35. These values hold through the range from 60 cycles to 5×10^9 cycles. Operating temperatures up to 90 deg. C. have little effect on electrical properties. Insulation resistance is too high to measure on conventional testing devices. BAKELITE Polyethylene excels in resistance to voltage breakdown, even after long-time water immersion.

BAKELITE

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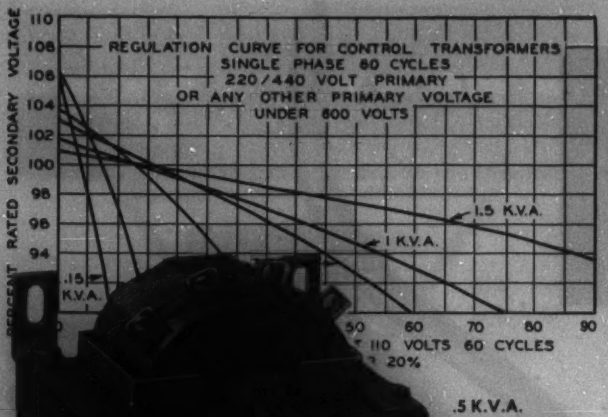
POLYETHYLENE

WIRE COVERING

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.



.5 K.V.A.
220/440-110 V.
TYPE S10

HEVI DUTY
CONTROL CIRCUIT
TRANSFORMERS
For Machine Tool and Other Industrial Controls

Hevi Duty control circuit transformers are specified by many machine tool and control manufacturers because of their superior and dependable performance. They are designed specifically for control circuits where high in-rush currents occur to provide better regulation of circuit voltage.

Write for Bulletin T-5111 for more complete information. This bulletin shows regulation curves, impedance characteristics, and presents other engineering data.

Hevi Duty control circuit transformers are designed to meet or exceed NEMA, ASA and JIC standards.

HEVI DUTY.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers *Constant Current Regulators*

(*Continued from page 28A*)

for faster, more accurate measurements of radio-relay, radar, television carrier systems, and similar applications involving superhigh frequencies. It is equipped with a reflex klystron oscillator for frequency generation. Accuracy and stability is high throughout the continuous frequency range of 3,800 to 7,600 megacycles. Frequency and voltage are directly set and read. Dial tuning is tracked automatically, and no voltage adjustment is required during operation. The equipment offers wide pulsing capabilities. It may be internally or externally pulse modulated. Repetition rate is continuously variable from 40 to 4,000 pulses per second. Pulse width is variable from 0.5 to 10 microseconds and also may be synchronized with an external sine wave, or with positive or negative pulse signals. For further information, write Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif.

Splice. A new splice that requires conductors to feed through the jaws has been developed by Reliable Electric Company, Chicago, Ill. The "55" Series Straight-line Splice is made of copper and copper alloys for copper conductors, and aluminum and aluminum alloys for aluminum conductors. Said to appear conventional externally, the new splice has openings only at tube ends, and even they are closed by pilot cups until conductors are inserted. The cups are factory installed in each end of the splice. They await the conductors and guide them "home." Pilot cups prevent a premature or false grip. Once the cups with conductors have been run through to center stop, the installation is complete and positive. Some of the advantages of the splice are: the pilot cups make it impossible for the jaws to grip conductor, unless conductor is properly "home"; it feeds through readily with a definite "feel" and "sound" when conductor strikes home; bent or out-of-lay strand or burred conductors cannot catch in the jaws; complete closure prevents entrance of gritty materials known to obstruct action of sliding tapers. For further information, contact F. A. Leach, manager, Specialty Sales, Reliable Electric Company, 3145 Carroll Avenue, Chicago 12, Ill.

Molded Composition Potentiometers. Dual Type *AB* molded composition potentiometers, consisting of two units mounted in tandem and controlled by the rotation of one shaft, are now being offered by Ohmite Manufacturing Company, Chicago, Ill. These 2-watt potentiometers are designed for industrial, laboratory, and radio, television, and electronic service applications where reliability is particularly important. The resistance element is a thick, solid-molded ring, heat treated under pressure, not a sprayed film of paint-type resistor. The new dual units have a 2-inch-long round shaft, and independent electric connections. For a complete description and dimensional

(*Continued on page 40A*)

Reliable Operation and Constant Timing . . . from Mechanically Stored Energy

115- to 230-kv 3-cycle
(Also other styles, 7.5 kv and up)

PACIFIC ELECTRIC Type RHE
HIGH-SPEED RECLOSING
CIRCUIT BREAKERS

to 10,000,000 Interrupting kva at 161 or 230 kv

RIGHT: View of Tank Tops, looking toward Tank No. 1, showing housings for opening springs and tube containing pull rod.

CENTER: Type RHE in TEXAS (138 kv).

FAR RIGHT: Interior of Mechanism Cabinet, showing both closing-spring barrels and motor-operated oil-hydraulic jack for spring compression.

THE MOTOR-Compressed operating springs of the PACIFIC Type RHE oil circuit breaker stand ready for action for years, if necessary, without anything meanwhile having to move or operate.

Directly connected to the crank arm of the blade unit in each tank is a set of external opening springs. In the end-mounted mechanism cabinet are the closing springs which act upon the pole units through a pull rod that is compensated for unequal stretch in its sections. Simultaneous operation is thereby assured at all poles.

Energy is stored in the closing springs by means of a motor-operated oil-hydraulic jack. Oil is under pressure only during the ten-second interval required for compression of the springs.

These features insure reliability of operation as well as constant closing time under all conditions . . . of special benefit when synchronizing.

Write for Catalog 585

PACIFIC ELECTRIC MFG. CORPORATION
5815 THIRD STREET, SAN FRANCISCO 24, CALIFORNIA
OTHER FACTORIES: SANTA CLARA, CALIFORNIA; GARY, INDIANA

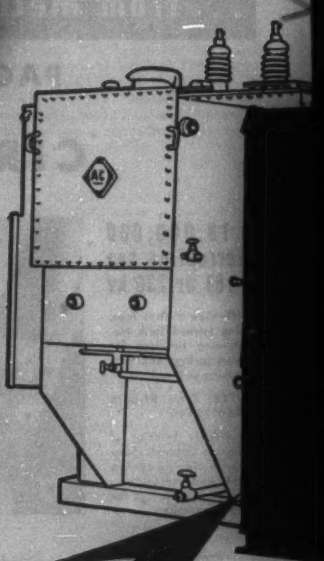
Since 1906

SALES OFFICES or AGENCIES in PRINCIPAL CITIES

MULTI-CIRCUIT

Unit Substations

Are Easy to Double-End



Now You Can Install A-C Unit Substations That Are Planned for Easy Future Double-Ending Without Service Interruption!

WHEN LOAD GROWTH demands additional power, or when you want the added reliability of two transformers, the Allis-Chalmers Unit Substations you install today will be easy to double-end.

Your line crew will find all mechanical and electrical connections easy to make . . . the transformer throat and switchgear bus easy to align. That's because sufficient mechanical flexibility is built into the throat to permit realistic tolerances in concrete base construction.

Design Aids Quick Field Assembly

Pre-drilled bus extensions are accessible and flexible enough to be consistent with throat construction. There are no compound-filled joints requiring melting, chipping, cracking, or scraping. Just apply no-corona tape and insulating tape to finish the job.

Double-ending is easy also in terms of system operation. When planned from the initial installation, double-ending can be accomplished with no interruption in power service to your customers. Even on substations not planned initially for double-ending, the job can be done with minimum outage.

Because Allis-Chalmers Unit Substations are designed to grow with your system, they are a convenient answer to the growing distribution problem . . . to the ever-increasing demand for power and yet more power. They are simple to specify, neat and modern in appearance, and easy to expand.

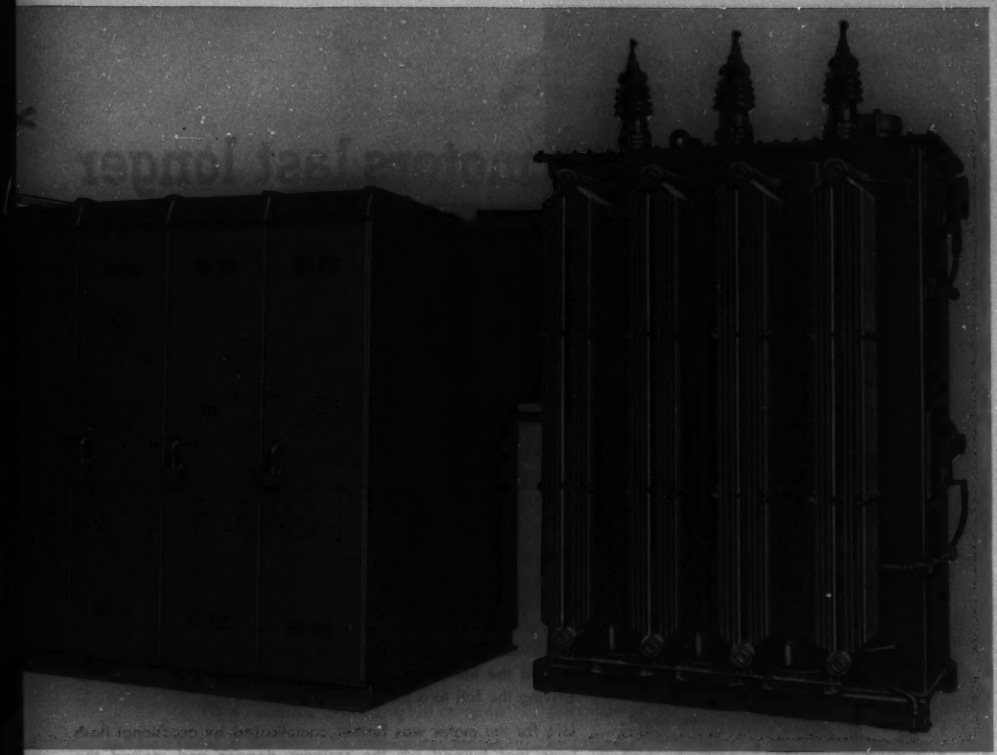
You Save These Five Ways:

(1) Original equipment cost is low; (2) compact construction reduces space requirements and real estate costs; (3) pre-wired unit design speeds installation; (4) maintenance is quick and economical because of improved accessibility; and (5) you purchase only the equipment you need *now*, deferring additional expenses until load growth demands the expenditure.

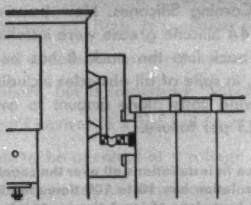
For the full story on what Allis-Chalmers Unit Substations can mean in your distribution system, call your nearby A-C representative, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3729

ALLIS-

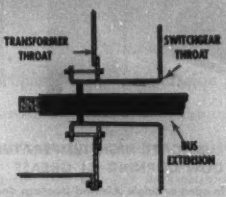


Here's Why It's Easy to Double-End MCS's



1 THE THROAT OPENINGS of all substation transformers, regardless of rating, are the same height as switchgear throat opening. This standardized throat location permits easy addition of a new transformer to the switchgear end of an installed Allis-Chalmers Unit Substation . . . simplifies and speeds field assembly.

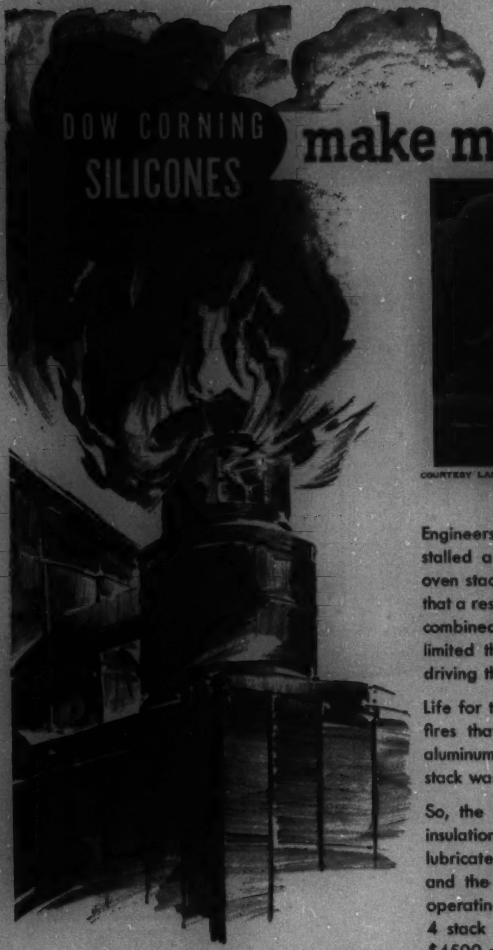
2 FEEDER UNITS are jig built so that each feeder cubicle is exactly like every other one. Bus extension openings, control wiring openings . . . even small screw holes . . . are pre-cut in jigs. This careful, uniform construction makes addition of a main breaker easy . . . assures easy alignment of the new transformer.



3 MECHANICAL AND ELECTRICAL connections are easy to make. Bus connectors and transformer throat are flexible enough to compensate for minor irregularities in concrete surfaces. Silver-plated, pre-drilled bus extensions are easy to bolt together. No-corona tape and insulating tape finish the joint.

CHALMERS

A-C ALLIS-CHALMERS



make motors last longer

COURTESY LAKEY FOUNDRY AND MACHINE COMPANY, MUSKEGON, MICHIGAN.

Saves $4500 in rewind costs; outlasts Class A 36 to 1

Engineers at the Lakey Foundry and Machine Company installed a 5-foot induced draft fan at the top of their core oven stack. It exhausted volatiles from the oven so effectively that a resinous deposit built up on the fan blades. This overload, combined with ambient temperatures in the range of 350°F, limited the life of the Class A insulated 7½ hp TEFC motor driving the fan to a month or less.

Life for the motor was further complicated by occasional flash fires that burned off the resinous deposit and melted the aluminum blades. And the cost of getting the motor out of the stack was greater than the rewind costs.

So, the motor was rewound three years ago with Class H insulation made with Dow Corning Silicones. New bearings lubricated with Dow Corning 44 Silicone grease were installed, and the motor was hoisted back into the stack. It has been operating steadily ever since, in spite of all obstacles including 4 stack fires. Savings in rewind costs alone amount to over $4500 at a conservative $125 per failure.

LUBRICATE HIGH TEMPERATURE BEARINGS WITH DOW CORNING 44 GREASE

In open or single shielded bearings designed for high temperature operation, Dow Corning 44 has many times the life expectancy of conventional greases. It gives life-time lubrication in permanently sealed cartridge-type bearings.

That kind of performance in installations all over the country proves that Class H insulation has 10 to 100 times the life expectancy of the next best class of insulating materials. It can also be used to increase the output of certain motors by as much as 50%.

mail this coupon Today

DOW CORNING CORP., Dept. H-6
Midland, Michigan
Please send me:
- ☐ Performance data on Class H equipment.
- ☐ List of Class H motor repair shops.
- ☐ Data on Silicone Grease for motor bearings.
- ☐ 32-page booklet entitled "What's A Silicone?"

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FIRST IN SILICONES

MIDLAND DOW CORNING CORPORATION MICHIGAN

Atlanta • Chicago • Cleveland • Dallas • New York • Los Angeles
Washington, D. C. • In Canada: Fiberglas Canada Ltd., Toronto • In England: Midland Silicones Ltd., London

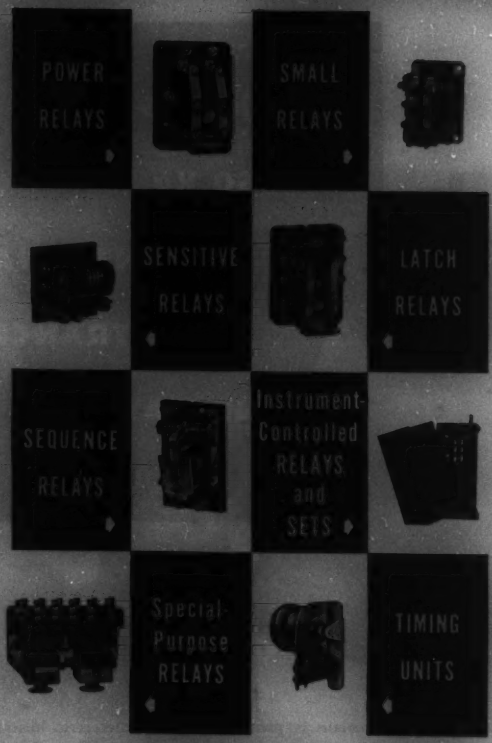
This insulator is designed to carry an antenna lead through the roof of a transmitter tuning house to an antenna. It is used at an effective operating voltage of 150 kv, and is the largest insulator of this type ever built—requiring a porcelain dome 32″ in diameter, 30″ high. It is similar to the Lapp standard series of antenna entering insulators for the broadcast industry, but is something "special" indeed in size—Lapp's answer to a demand from the field for an insulator to be operated at a voltage considerably higher than previously encountered in broadcast practice.

This design is significant, in addition to its large size, for the ingenuity of its shielding provisions. The porcelain is protected against dielectric heating internally, opposite the flange, and externally, at the narrow top section.

Many suppliers of equipment to the electrical transmission, as well as radio industries, look to Lapp for engineering, design and production of special parts involving use of high-voltage or low-loss ceramics. They know, as do operators of transmission and distribution systems across the nation, that the name LAPP guarantees an extra margin of operating security. For, although *you can buy cheaper porcelain—you can't buy better porcelain*—than LAPP.

Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp



STRUTHERS-DUNN

Standard relays and timers match 4 out of 5 requirements

5,348 RELAY TYPES

S-D

STRUTHERS-DUNN, INC., 150 N. 13th St., PHILADELPHIA 7, PA.

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ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(*Continued from page 34A*)

drawings of these potentiometers, write to Ohmite Manufacturing Company, 4897 Flournoy Street, Chicago, Ill., requesting Bulletin *131B*.

Ultrahigh-Frequency Transmitting Antenna. A new 2-bay 24-wave-length-section slot-type ultrahigh-frequency transmitting antenna has been announced by the Television Transmitter Division of the Allen B. Du Mont Laboratories, Inc., Clifton, N. J. The new antenna has been cataloged as the Type *5327-A*. Outstanding among the many features is the uniform coverage provided throughout the desired area, as required in most installations. The vertical beam of the antenna approaches within 6 decibels of the ideal distance versus signal strength cosecant curve. The antenna can be electrically and mechanically tilted to provide the vertical pattern desired in any particular installation as Type *5327-A* (modified). In this manner, the basic Du Mont antenna design can be used for installations usually requiring expensive custom-designed antennas.

Fiberglas Duct Liner. A new Fiberglas insulating product for lining the interior of air-conditioning or warm air ducts has been introduced by Owens-Corning Fiberglas Corporation, Toledo, Ohio. Known as Flexible Duct Liner, the insulation has a high noise reduction efficiency and thus effectively reduces sounds that normally travel through air ducts. It also has excellent thermal insulating properties and when used inside of ducts allows the metal surface to act as a vapor barrier, thus preventing condensation on those ducts carrying cool air through areas of high humidity.

Heavy-Duty Rotary Switches. Two single-deck single-pole rotary switches designed for complicated range or circuit switching of experimental apparatus or heavy-duty test equipment, have been announced recently by the Shallcross Manufacturing Company, Collingdale, Pa. Both the 60-position (Type *10061-S*) and the 36-position (Type *10054-S*) models have a unique detent mechanism which also provides the non-short-circuiting action. The rotor arm is actually lifted as it moves from one contact to the next thus allowing the maximum number of usable contacts in the smallest space. Large solid silver contacts mounted on a laminated phenolic deck result in an average contact resistance of less than 0.006 ohm. The current-carrying capacity of the Type *10054-S* is 40 amperes, with breakdown voltage of 2,500 volts. The 60-position Type *10061-S* will carry 30 amperes, and has a breakdown of 1,500 volts. Further details are available on letterhead request to the manufacturer.

Function Plotter. The ElectroniK Function Plotter can be used to advantage

(*Continued on page 52A*)

BUTYL-MOLDED, OPEN-WINDOW DESIGN JKP-0 indoor-outdoor versatility. Cut your stock and inventory costs with JKP-0 indoor and outdoor 600-volt applications.

4 in 1

NEW G-E CURRENT TRANSFORMER REPLACES 4 STANDARD MODELS

An outstanding advantage of the Type JKP-0, 600-volt butyl-molded current transformer is its versatility —it easily replaces 4 different types. Here are four ways the JKP-0 saves you money:

1. STOCKING COSTS REDUCED. Standardizing on the JKP-0 cuts costs by reducing stock requirements, simplifying ordering.

2. MAINTENANCE IS REDUCED. JKP-0 transformers will not corrode, breakage is reduced, no painting is needed—JKP-0 is butyl-molded.

3. INSTALLATION COSTS CUT. The JKP-0 does not require elaborate arrangements of crossarms, hanger connections, etc.—and the amount of wiring is reduced.

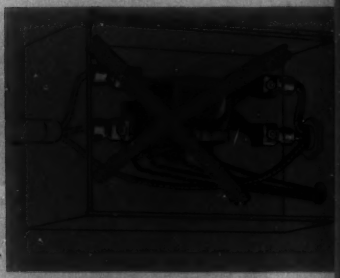
4. LOWER INITIAL COST. This versatile transformer sells for less than most of the conventional types it replaces.

Write or call your nearest G-E Apparatus Sales Office, or authorized agent or distributor. Ask for Bulletin GEA-5874. General Electric Company, Schenectady 5, New York. 604-38

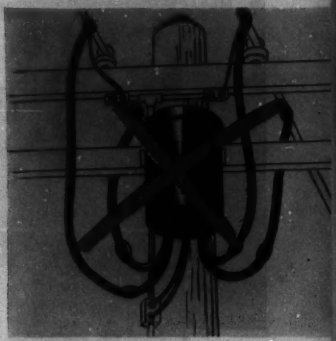
You can put your confidence in—

GENERAL ELECTRIC

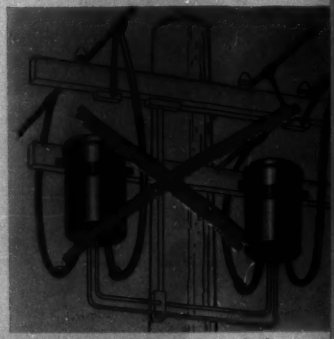
REPLACING INDOOR JL-1 (or newer JKR-0) with the JKP-0 means simplified wiring, fewer connectors—cut costs!



CARRY ONE MODEL in stock instead of four! Above: JKR-1, another transformer easily replaced by the new JKP-0.



FOR OUTDOOR JOBS the JKP-0 eliminates costly crossarms and connectors demanded by conventional Type JKB-1.



ANOTHER OPPORTUNITY to standardize is realized when butyl-molded JKP-0 replaces JKB-2 outdoor current transformer.

Outdoor connections at switch yard. Note manually prepared terminals.

The 600 volt cable for motor connections and single conductor control cable was RoMarine-RoPrene, style RR-D. All sizes from No. 12 to 1000 CM style RR-D were used for this service.

Multi-conductor control cable in this installation is RoLene (polyethylene) insulated and Rome Synthinol sheathed, described by Rome Cable specification CT-2.

Recently built Kaiser Steel Tin Plate Mill (left foreground), Fontana, California. Capacity is 200,000 tons of tin plate per year.

Electrical Contractor:
Kaiser Engineers, Inc.

How Kaiser Steel licked 3 tough cable problems all at once

In selecting power cables for 6.9 KV circuits at its new Fontana Tin Plate Mill, Kaiser Steel Corporation faced three knotty problems:

First, the hazard of acid and alkali corrosion was severe.

Second, the threat of electrolytic action was more than a possibility.

Third, termination and splicing costs were important factors.

Kaiser's choice for this service fell to single conductor, 500,000 CM Rome RoZone-RoPrene shielded power cable, insulated for 9 KV. Two sets were installed to connect the main substation with two 6,900 volt busses in the tin mill proper. Total connected load to the busses was 19,000 HP of M-G motors and 14,250 KVA of transformers.

Why RoZone-RoPrene

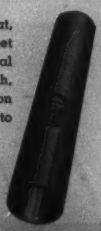
RoZone insulated, RoPrene sheathed cables offer maximum protection against acids, alkalies, oils, greases, moisture, heat, sunlight, and flame. They are non-metallic sheathed and require no lead sheaths. Their RoZone (premium quality oil base) insulation provides exceptional resistance to corona action and ozone cutting.

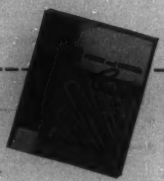
Simple manual terminations eliminate the need for potheads. Standard splicing kits only are needed; no costly wiped joints. And the smooth surface of the RoPrene (Neoprene compound) sheath makes for easy working and pulling through conduits and junction boxes.

HELPFUL INFORMATION—Whether your electrical requirements involve special cable designs to meet severe service conditions or simple home wiring, consider the advantages Rome products offer from the standpoint of price and quality. For information that you may find immediately useful, send for the *Rome Power and Control Cable Catalog* illustrated below.

500,000 CM, single conductor shielded, RoZone-RoPrene power cable, rated at 9 KV.

To give wires and cables added protection against heat, moisture, corrosion and abrasion, several thousand feet are encased in Rome • EMT. This is a superior electrical metallic tubing, electrically welded for extra strength, with an electrogalvanized exterior surface for protection against corrosion and a mirror-smooth interior surface to prevent cable injury.





You'll get a wealth of helpful information from the Rome Power and Control Cable Catalog. It contains 65 pages of illustrated information, specification and test data on all Rome power and control cables and on famous Rome insulations. Mail the coupon for your copy today.

ROME CABLE CORPORATION,
Dept. EE-6, Rome, N. Y.
Please send me a copy of the Rome Power and Control Cable Catalog.

Name.....
Company.....
Address.....
City..... Zone..... State.....

It Costs Less to Buy the Best!

ROME CABLE
Corporation
ROME • NEW YORK
and
TORRANCE • CALIFORNIA

Ketay gives you a complete variety of sizes and types of Synchros and Servo Motors

WHATEVER THE NEED CHOOSE KETAY!
Available as listed

1. SYNCHRO, Size 16, O.D. 1.537", 115 V, 400 Cycles *(Transmitter, Receiver, Control Transformer)*
2. INDUCTION MOTOR, O.D. 1.750", 3 phase 2 Pole, 115 V, 60 Cycles
3. SYNCHRO, Size 18, O.D. 1.750", 115 V, 400 and 60 Cycles *(Transmitter, Receiver, Differential, Control Transformer)*
4. SERVO MOTOR, O.D. .937", 26V, 400 Cycles
5. SYNCHRO, O.D. 1.437", 14.4 V and 26 V, 400 Cycles *(Transmitter, Receiver, Resolver, Differential, Control Transformer)*
6. SERVO MOTOR Mk 7, O.D. 1.437", 115 V, 400 Cycles
7. SYNCHRO, Type 1F or 1HG, O.D. 2.250" 115 V, 60 Cycles *(Receiver, Transmitter)*
8. SYNCHRO, Size 31, O.D. 3.10", 115 V 400 and 60 Cycles *(Transmitter, Receiver, Differential, Control Transformer)*
9. SYNCHRO, Size 23, O.D. 2.250", 26 V and 115 V 400 & 60 Cycles *(Transmitter, Receiver, Resolver, Differential, Control Transformer)*
10. SYNCHRO, O.D. .937", 26 V, 400 Cycles *(Transmitter, Receiver, Resolver, Differential, Control Transformer)*
11. LINEAR TYPE CONTROL TRANSFORMER, O.D. 1.625", 26 V, 400 Cycles
12. SYNCHRO, Size 11, O.D. 1.062", 26 V and 115 V, 400 Cycles *(Transmitter, Receiver, Resolver, Differential, Control Transformer)*
13. SERVO MOTOR, O.D. 1.062", 115 V, 400 Cycles
14. SYNCHRO, Size 15, O.D. 1.437", 26 V and 115 V, 400 Cycles *(Transmitter, Receiver, Resolver, Differential, Control Transformer)*
15. SYNCHRO, Size 19, O.D. 1.90", 115 V, 400 Cycles *(Transmitter, Receiver, Control Transformer)*

KETAY offers high precision rotary and instrument components for most every need in the Armed Forces and Industry. As the world's largest producer of government approved synchros, Ketay stands ready to solve your problems with a complete line of synchros, servos, magnetic amplifiers, computers and control systems.

If you are searching for a specific size or type... if availability is a problem... if engineering counsel is needed... Ketay can help. Why not join us for an exploratory discussion of your particular problem. Write today to Dept. E

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KINETIX INSTRUMENT DIV.
DESIGN
RESEARCH & DEVELOPMENT DIV.
DEVELOPMENT
PACIFIC DIVISION
12833 Simms Ave., Hawthorne, Calif.

MANUFACTURE ...of precision instruments, components, and systems.

IT TAKES MORE THAN THIS HAMMER BLOW TO INJURE—

Victor Insulators

See that hammer falling? It's about to strike the outer edge of a Victor Suspension Insulator with a force that greatly exceeds any it encounters. This is routine control procedure in Victor's test laboratories. It proves that insulators made of *Victrest Porcelain* consistently withstand impacts in excess of NEMA standards. This finest porcelain ever made is more dense, harder, tougher and far more resistant to impact than any other porcelain yet developed. For full data on Victor Suspension Insulators, write for Bulletin No. 1.

Victor Suspension Insulators are tested in the laboratory before they are shipped to customers.

FREE BOOKLET ... [illegible] ... Victor Insulators ... [illegible] ... Victor Insulators.

Specify

VICTOR INSULATORS, INC., VICTOR, N. Y.

Line and High Voltage Fittings • Suspensions • Guy Strain Insulators • Switch and Bushing Insulators • Custom Designed Porcelains

Vol. 72
1953

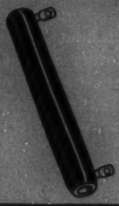
OHMITE *Wire-Wound* RESISTORS

Built FOR LONG LIFE AND DEPENDABLE OPERATION

EVEN, UNIFORM WINDING

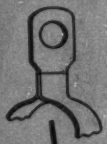
The unsurpassed uniformity of the resistance winding prevents "hot spots" and resultant failures. This uniformity is *permanent* — locked in by vitreous enamel.

VITREOUS ENAMEL COVERING



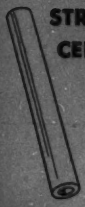
Acts as both heat conductor and electrical insulator. Holds the winding rigidly in place, and protects it against mechanical damage, moisture, and fumes.

TINNED TERMINALS



Terminal lugs are tin-dipped for ease in soldering to connecting wires. Resistance wire is welded or brazed to the lug, assuring perfect electrical connection.

STRONG CERAMIC CORE



The high-strength ceramic tube provides a sturdy insulating base for the resistance winding. It is unaffected by cold, heat, fumes, or high humidity.

RESILIENT MOUNTING BRACKETS

Hold resistor firmly in place, yet have resilience to prevent shock damage. Brackets are simple to attach; can be easily removed by a slight upward pressure at the base.

OHMITE MANUFACTURING CO.
4835 Flournoy Street, Chicago 44, Ill.

Write on Company Letterhead for Complete Catalog

Be Right with

OHMITE®

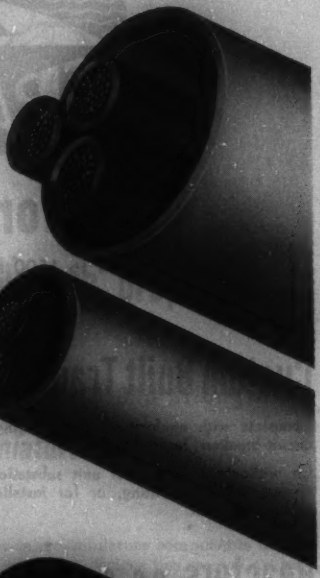
RHEOSTATS • RESISTORS • TAP SWITCHES

LOAD FOR LOAD!

ROCKBESTOS A.V.C.®

(N.E.C. TYPE AVA)

COSTS LESS INSTALLED

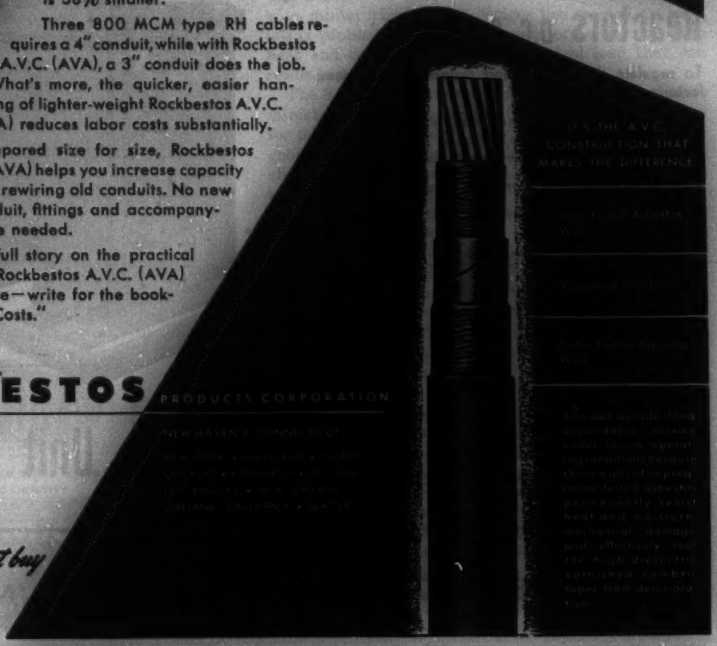


For example, take a 430 ampere load at 40°C Ambient temperature. To use type RH cable, an 800 MCM is required but with Rockbestos A.V.C. (AVA), a size 500 MCM cable carries the same load and is 38% smaller.

Three 800 MCM type RH cables requires a 4" conduit, while with Rockbestos A.V.C. (AVA), a 3" conduit does the job. What's more, the quicker, easier handling of lighter-weight Rockbestos A.V.C. (AVA) reduces labor costs substantially.

Compared size for size, Rockbestos A.V.C. (AVA) helps you increase capacity simply by rewiring old conduits. No new larger conduit, fittings and accompanying labor are needed.

To get the full story on the practical advantages of Rockbestos A.V.C. (AVA) high ampere cable—write for the booklet "—Cut Cable Costs."



ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN 5, CONNECTICUT

Hi® ...Your best buy

SORGEL AIR-COOLED Dry-Type TRANSFORMERS

for Every Purpose

¼ to 1500 Kva single phase. 1 to 3000 Kva poly-phase.
All voltages up to 15,000 volts.

Custom Built Transformers

Complete with enclosures, tap changing switches, circuit breakers, fuses, meters, etc.

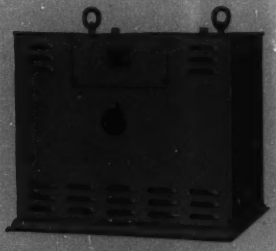
Or without enclosures for unit substations, power centers, panel mounting, or for installation with other equipment.

Reactors D.C. Saturable

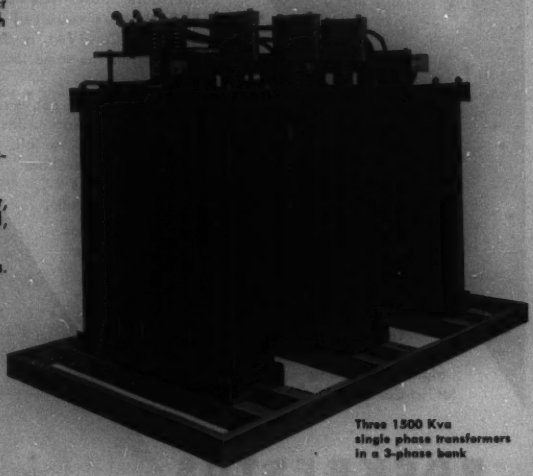
To regulate the voltage and current of any manufacturing process.

The control can be a small, simple potentiometer, with stepless adjustments, or push button control, placed in any desired convenient location.

Ask us to help you work out your requirements.



D.C. Saturable Reactor with potentiometer control



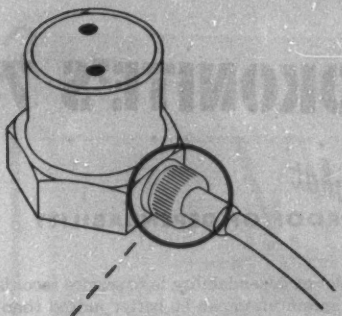
Three 1500 Kva single phase transformers in a 3-phase bank

for Unit Substations

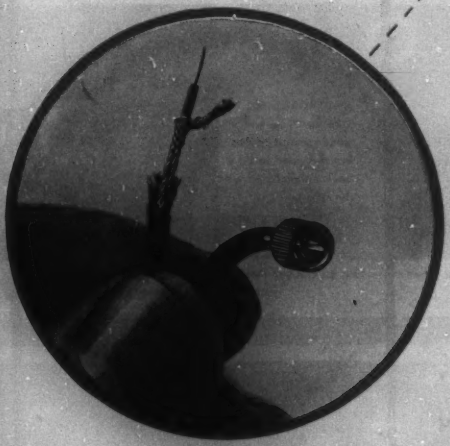
Sales Engineers in Principal Cities

SORGEL ELECTRIC CO., 846 West National Ave., Milwaukee 4, Wis.

Pioneers in the development and manufacturing of Air-Cooled Dry-Type Transformers — Over 35 Years



Du Pont TEFLON* provides excellent dielectric properties...



Coaxial connectors and cable made by Microdot Division, Felts Corporation, S. Pasadena, Calif.

...heat resistance and strength in new miniature parts

The demand for micro-miniature components in scale with miniaturized circuit designs has created an insulating problem. Miniature circuits often develop high heat and carry an increased electrical load that can result in failure of these tiny components.

The Felts Corporation faced such a problem with its miniature coaxial connector. They needed a material for the connector and primary wire insulation that had good dielectric properties and a wide resistance to heat, chemicals and corrosion. It also had to be moisture-resistant and strong.

After testing many materials, they chose Du Pont "Teflon" tetrafluoroethylene resin. "Teflon" is an excellent insulator. It has a dielectric constant of 2.0 and a loss factor of 0.0005. Its power factor is less than 0.05% even at frequencies as high as 30,000 megacycles. And these dielectric properties are unaffected by temperatures from -80°F. to 500°F. Du Pont "Teflon" is inert to all chemicals except molten alkali metals and fluorine. It is tough and durable—will not crack or arc. "Teflon" has zero water absorption and helps reduce self-generated noise at high termination impedances.

Du Pont "Teflon" serves many uses in electrical equipment—stand-off and feed-thru insulator terminals, insulation for wire, cables and motor windings, and other parts where high temperatures, dielectric strength and durability are required. Perhaps "Teflon" can help you improve or develop a product. For full information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 216T, Du Pont Bldg., Wilmington 98, Delaware.

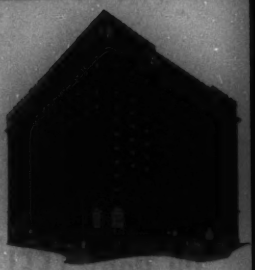
*REG. U. S. PAT. OFF.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

OKONITE'S 75TH ANNIVERSARY

Here's what PROOF OF DEPENDABILITY

The real proof of dependability is in service records, for no claim or specification can be better judged than by the passage of time. The best example of Okonite's dependability is that Okonite cable, which was already in use before the electric light was invented, is in increasing demand today



LONG SERVICE LIFE. An Okonite cable, after 36 years of service in the old Hotel Gibson, was reinstalled in the new hotel erected on the site.

Here's what PROOF OF VERSATILITY

Small low voltage cables or large high voltage transmission systems are all within the scope of Okonite manufacturing experience. Whether underwater, underground or aerial, Okonite has developed wires and cables that operate continually under the severest tests that such installations can impose.

UNDERGROUND. Okolite-Okoprene underground cables are designed to be buried directly in the ground.

Here's what PROOF OF CUSTOMER SATISFACTION

Wherever electricity is transmitted, whether in large blocks of power or for sensitive low voltage control, Okonite has been specified in orders and re-orders. The wide-spread use of Okonite wires and cables is proof of Okonite's acceptance as a leader in the field.

Utilities, railroads and industry recognize the fact that there is no substitute for experience . . . and that the Okonite symbol is the guarantee of quality. The Okonite Company, Passaic, New Jersey.

UTILITIES. Utility companies use Okonite cables for such varied purposes as control cable, transformer and generator leads, and transmission lines.

insulated cables . .

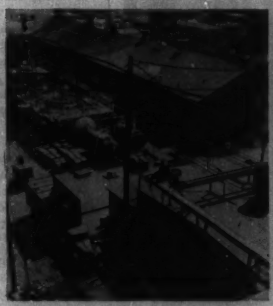
means... what?

REPEAT PERFORMANCE. This first motor-operated electric semaphore signal was powered through Okonite—as is today's modern counterpart on the same site.

MULTIPLE INSTALLATIONS. Installed in 1941, these 34.5 kv Okolite submarine cables supplement an existing pair of 34.5 kv cables installed in 1931.

AERIAL. Okolite-Okoprene self-supporting cables can be installed quickly, easily and economically.

UNDERWATER. Okolite insulation requires no lead sheath even when totally submerged.

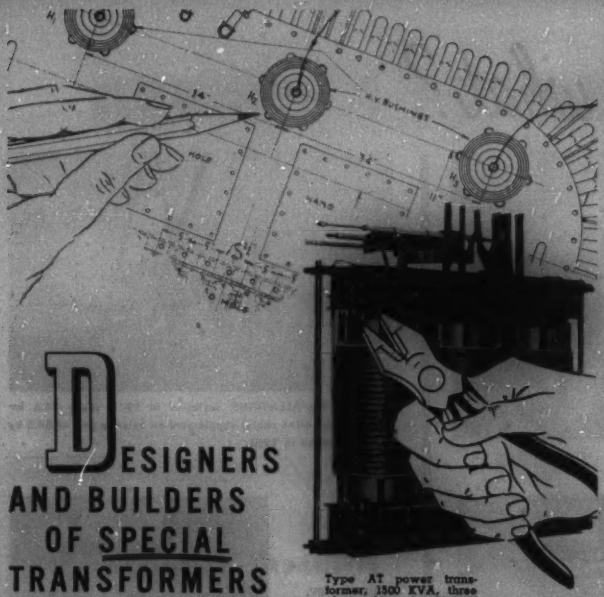


INDUSTRY. From power distribution to production machinery, Okonite cables play an important part in industry.

TRANSPORTATION. Classification yards, powerful diesels, signal systems, and passenger cars depend on Okonite cables for uninterrupted service.

• ***products of on-the-job experience***

75 ANNIVERSARY



DESIGNERS AND BUILDERS OF SPECIAL TRANSFORMERS

Type AT power transformer, 1500 KVA, three phase, 60 cycle, 69,000Y volts primary, 240/480 volts secondary. Core and coil assembly, low voltage side.

DESIGNING . . . Designing transformers for special functions is a service STANDARD engineers are well qualified to render. You can save time by using STANDARD'S design service when ordering transformers for specific projects, including power, distribution, metering and testing.

BUILDING . . . Your specially designed transformers are manufactured under the watchful eyes of the designing engineers. Every step in the process of manufacture is performed by skilled transformer specialists. ASA standards are met or exceeded. Call your nearest STANDARD representative for information on this useful service.

Type ATAB power transformer, 1500 KVA, three phase, 60 cycle, 69,000Y volts primary, 480/240 volts secondary. Equipped with hot spot temperature indicator and control, provisions for future forced air cooling, pedestals for mounting station type lightning arresters, low voltage terminal chamber and automatic gas seal equipment.

THE Standard

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 40A*)

wherever there is occasion to depict graphically one variable as a function of another ($y=f(x)$). It plots such curves with speed and accuracy. Measurements over the entire curve are continuous, and it is not necessary to interpolate to complete data between points of measurement. This saves much time in investigation involving interdependent nonlinear variables. The measuring circuit of each axis can be energized by any d-c source, so that a wide variety of investigations can be made. Direct inquiries to Station 64, Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 44, Pa.

TRADE LITERATURE

Selection Guide. Tips on selecting the right starter for squirrel-cage induction motors rated up to 600 horsepower at 600 volts or less are contained in a new bulletin released by Allis-Chalmers Manufacturing Company. Information included in the bulletin tells how to select the proper type of starter, enclosure, and operating arrangement, and explains how to determine whether a full- or reduced-voltage starter should be used. An explanation of 2- or 3-wire control and hints on selection of heater elements for overload relays are also given in the bulletin along with a cage-motor starter selection chart. Copies of this Allis-Chalmers selection guide for general-purpose starters, *14B7733*, are available upon request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Permanent Magnets. Thomas & Skinner Steel Products Company, Inc., Indianapolis, Ind., has released a catalogue listing its complete line of standard permanent magnets. Available in Alnico *2*, *3*, and Alnico *5* for use in a wide range of industrial applications, Thomas & Skinner standard magnets may be ordered from stock to aid designers and engineers who want magnets quickly to produce working models for experimental purposes, to fulfill moderate production requirements, or to adapt to a standard application without tooling delays. For Standard Magnet Catalog Number *1252* write to Thomas & Skinner Steel Products Company, Inc., 1154 East 23d Street, Indianapolis 5, Ind.

"Mylar" Polyester Film. A new technical bulletin containing up-to-date information on the physical, electrical, and chemical properties of "Mylar" polyester film, and suggested applications, has been issued by the du Pont Film Department. First of a series to be issued on "Mylar," the new 14-page bulletin (number *1-2-53*) is complete with charts, diagrams, and tables. In addition to a detailed table on the physical properties, the bulletin compares these properties with those of the other

(*Continued on page 54A*)

RUGGED

DEPENDABILITY of ANDERSON

DISTRIBUTION CONNECTORS TYPES 'K' & 'KR'

MEANS UNINTERRUPTED POWER SERVICE

☆ ABW DESIGN MEANS QUALITY *Plus* STRENGTH IN THE RIGHT PLACES!

7 OUTSTANDING SERVICE FEATURES:

- Each component is of a special alloy for high strength, and achieves a specific electrical and mechanical function.
- Flexing arch type clamping members retain high pressure contacts on cables during vibration and temperature changes.
- Transmits high pressure contacts from connector clamping members through each cable strand to core wire.
- Limits high resistance oxide formations on connector contact and cable interstrand contact surfaces.
- Eliminates connector failures resulting from heavy short circuit current surges passing through oxide contamination on connector and cable interstrand contact surfaces.
- Withstands Mercurous Nitrate Specification ABW-124-1* which insures against seasonal and stress corrosion cracking failures.
- Two styles, "KR" with conductor spacing bar, "K" without. Both "K" and "KR" series include 7 sizes for cables from #8 to 1000 MCM.

* Identical to ASTM B-154-45 Mercurous Nitrate Specification except ABW-124-1 specifies stressed components which is a more severe test.

WRITE TODAY... for Bulletin K-175 containing complete data on Anderson Distribution Connectors Types "K" and "KR"
OR CONSULT YOUR NEAREST ABW REPRESENTATIVE.

ABW

Aluminum and Bronze POWER CONNECTORS • CLAMPS • FITTINGS and ACCESSORIES for

ANDERSON BRASS WORKS INCORPORATED

BIRMINGHAM, [illegible] ALABAMA

SUBSTATION — TRANSMISSION — DISTRIBUTION

the Waterman

RAYONIC®

CATHODE RAY TUBES

ANOTHER EXAMPLE OF Waterman PIONEERING...

Waterman RAYONIC CATHODE RAY TUBES have reached still greater heights. Since the introduction of the Waterman RAYONIC 3MP1 for miniaturized oscilloscopes and the Waterman developed rectangular 3SP CATHODE RAY TUBE, scientists in our laboratories have diligently searched for a more perfect answer to the perplexing problem of trace brightness versus deflection sensitivity. The 3XP RAYONIC CATHODE RAY TUBE is their answer to providing a brilliant and sharply defined trace and high deflection sensitivity at medium anode potentials. When the 3RP or 3SP tubes are operated at 1000 Volts second anode and compared against the 3XP at 2000 Volts on the second anode, the results are astonishing. For the same size spot, the 3XP light output is improved by a factor of 4 and its vertical sensitivity is improved by a factor of 2, with the horizontal sensitivity remaining equal to that of the other tubes. Because the 3XP is enclosed in a shorter envelope and is equivalent to the 3RP and 3SP with respect to interelectrode capacities, it lends itself readily for high frequency video work, as well as for low repetitive operation.

3XP TECHNICAL DATA

SIZE:	
FACE	1½ x 3 inches
LENGTH	8.875 inches
BASE	Loctal
TYPICAL OPERATING CONDITIONS	
FILAMENT	6.3 Volts
	0.6 Amps.
ANODE #2	2000 Volts
	Max. 2750 Volts
ANODE #1	400 to 690 Volts
GRID #1	—22.5 to —67.5 Volts
DEFLECTION FACTOR IN VOLTS/INCH	
D1 to D2	68 to 92
D3 to D4	25 to 35

AVAILABLE in P1, P2, P7, and P11 Phosphorf

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKEITSCOPE

WATERMAN PRODUCTS INCLUDE
3JP1 & 3JP7 JAN RAYONIC CR TUBES
3JP2 & 3JP11 RAYONIC CR TUBES
3MP7 & 3MP11 RAYONIC CR TUBES
3RP1, 2, 7, 11 RAYONIC CR TUBES
3SP1, 2, 7, 11 RAYONIC CR TUBES
POCKETSCOPES PULSESCOPES
RAKESCOPES
And Other Associated Equipment

MEMO... Write for details today!

WATERMAN PRODUCTS

(*Continued from page 52A*)

du Pont films: cellophane, polyethylene, acetate. One section gives complete information on the film's electrical properties: dielectric strength, insulation resistance, volume and surface resistivity, and so forth. The chemical properties section shows the tensile strength and tear resistance of "Mylar" upon exposure to solvents, acids, and other chemical reagents. Copies may be obtained from the du Pont Film Department's Sales Development and Technical Service Section, Wilmington 98, Del.

Motor-Generator Reference Booklet. A motor and generator reference booklet to assist in the selection of motive power to handle most industrial applications is being made available by Allis-Chalmers Manufacturing Company. The 50-page pamphlet is reprinted from the 1952 edition of Lincoln's Industrial-Commercial Electrical Reference published by the Electrical Modernization Bureau, Inc. Text and illustrations on integral-horsepower motors and generators for the book were furnished by Allis-Chalmers in co-operation with the Electrical Modernization Bureau. Copies of "Allis-Chalmers Motor and Generator Reference Book," *51R7933*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Lamp Catalogue. A new, full-color Large Lamp Catalogue has been announced by General Electric's Lamp Division, with headquarters at Nela Park, Cleveland, Ohio. Entirely new in format, the 72-page catalogue replaces a volume published in 1948. It is the most elaborate and complete lamp catalogue yet to be issued by General Electric. Purpose of the catalogue is to show and describe briefly the popular types of G-E lamps available for many important lighting services. Buyers and sellers of lamps are expected to find it of great assistance in determining sizes and types needed, and for properly identifying individual lamps. The publication presents much information about the construction, operation, and application of lamps for the guidance of the book's users. Carrying price of 70 cents, the Large Lamp Catalogue is intended for persons interested in lamps and lighting in a professional or business way.

Electron Tubes. An up-to-date "Who's Who" of RCA electron tubes which describes 495 different receiving types and kinescopes is available from RCA tube distributors. The new booklet entitled, "RCA Receiving Tubes for AM, FM, and Television Broadcast" (Form Number *1275-F*), was designed to provide service dealers with an up-to-date catalogue of RCA receiving tube information and to serve as a guide to the selection of the most suitable tube for a given application. Contained in the 24-page booklet are characteristics of each of the 495 tube types, together with socket connection diagrams arranged for quick and easy reference. Information on RCA television picture tubes is presented in a special chart which

(*Continued on page 62A*)

BIDDLE
Instrument News

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

JAMES G. BIDDLE CO., 1316 ARCH ST., PHILADELPHIA 7, PA.

Tips on TESTING . . .

Concerning Low Resistance Measurements of Cable and Conductor Joints

High-resistance joints in cables and conductors are a major source of trouble in electrical circuits, and one of the chief uses of the "Ducter" Low Resistance Ohmmeter is in combatting such conditions. High-resistance joints cause objectionable voltage drops, loss of power, and damage from localized heating.

A few mental excursions into Ohm's Law will reveal the fact that a small fraction of an ohm in high-current circuits can equal an appreciable number of volts, and will result in lost kilowatts. Circuits normally having low resistances, say in the order of 11,000 microhms (.011 ohm), which is equivalent to about 1,000 feet of 1,000 mcm cable, could easily have defective joints that would double that value. If this cable is rated at 370 amp., the voltage drop would be 100% above normal, or a total of 8 volts, and would waste 36 kwhrs per 24-hour day above the normal loss.

Such defective joints can be discovered by evidences of heat, or by measuring the voltage drop during normal load periods. These methods are not as simple as measuring the cold resistance of the joints, either when they are installed or during off-load periods. Any well-made joint should have a resistance between the points measured not greater than the same length of the cable or conductor involved. This would mean, in the case of the 1,000 mcm cable previously mentioned, that any joint in its length within a space of one foot should not exceed 11 microhms (.000011 ohm). The "Ducter" Low Resistance Ohmmeter measures values down to 1 microhm (.000001 ohm).

Useful Formulas

The foregoing value of 11 microhms is determined as follows:

$R = \rho \frac{l}{a}$ where $\rho = 10.7$ ohms/cm. ft. at 20° for 97% conductivity copper. l = length in feet, a = area in circular mils.

$$R = \frac{10.7 \times 1}{1{,}000{,}000} = .0000107 = 10.7$$

microhms.

This calculation is given here for convenience so that users may be reminded of the method of determining the resistance of any conductor. The following formulas will also be helpful.

Rectangular or square-shaped conductors:

$$\text{Circular mils} = \text{cm} = \frac{\text{sq. mils}}{.7854} = \frac{\text{in.}^2 \times 10^6}{.7854}$$

For round conductors:

$$\text{Circular mils} = \text{cm} = (\text{dia. in mils})^2$$

NOTE: The above material is taken from our Instruction Manual for use with the Ducter Low Resistance Ohmmeters. In it is valuable information including "Resistance Network Data", "Temperature Data" and many tables, diagrams and formulas to help those men concerned with low resistance measurement problems. We will be glad to send you a copy of this manual without obligation. Just write on your company letterhead for **MANUAL 24J-EE.**

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

FOR RELIABLE LOW RESISTANCE MEASUREMENTS

Select One or More of These MEGGER® INSTRUMENTS

1. Midget Megger Circuit Testing Ohmmeter—measures down to .1 ohm. Battery supply.
2. Bridge-Meg Resistance Tester—Measures down to .01 ohm. Hand generator operated.
3. Megger Low Resistance Ohmmeter—measures down to .000010 and .000100 ohms. Either battery or rectifier operated.
4. Ducter® Low Resistance Ohmmeter—measures down to .000001 ohm. Battery or rectifier operated.

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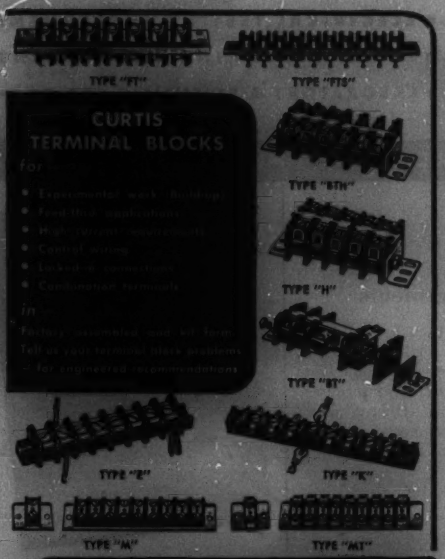

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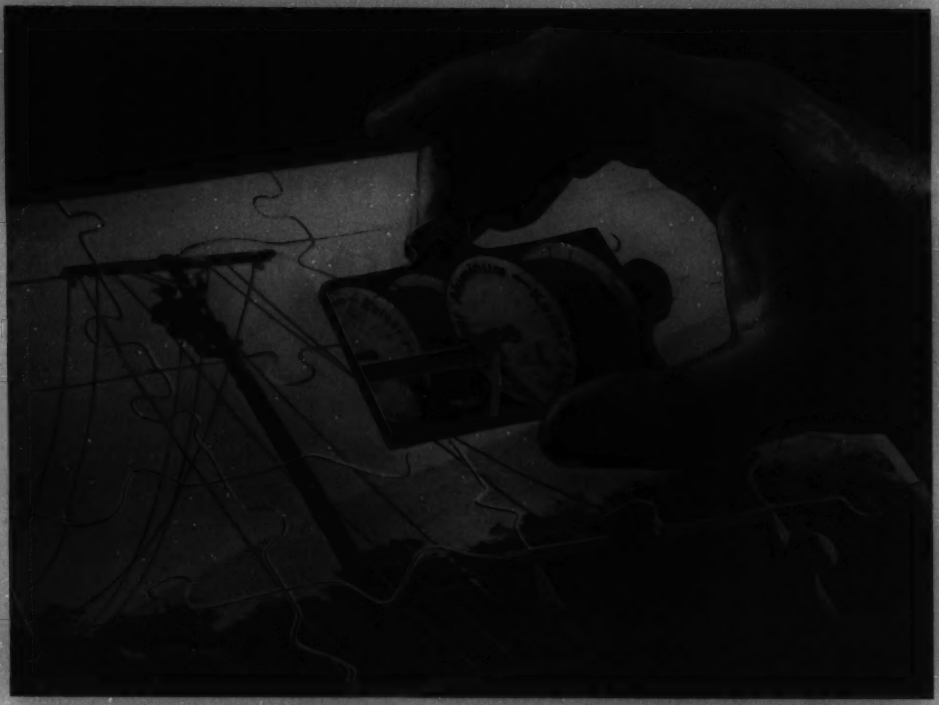

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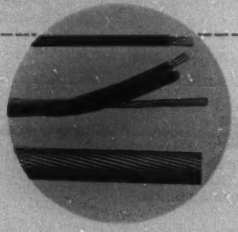

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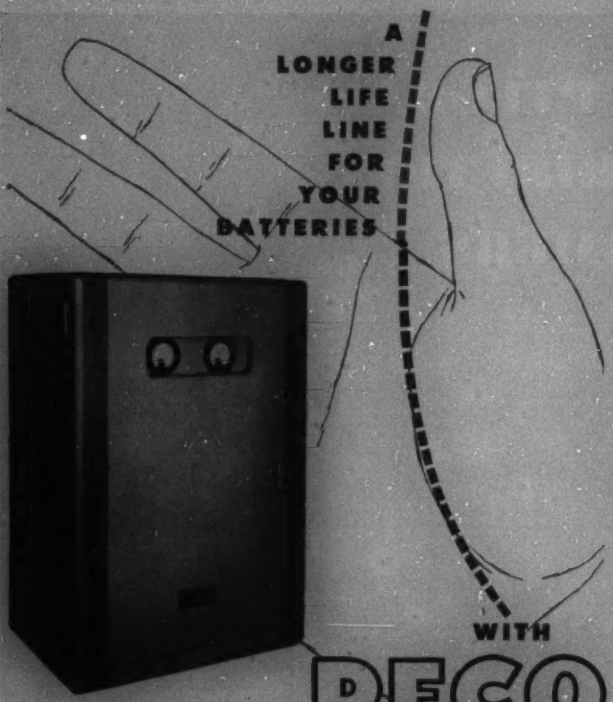

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AIEE Special Publication S-54 contains papers and discussions presented at the Conference on Telemetering and Remote Control sponsored by the AIEE and the Institute of Radio Engineers (IRE) and held at the Lafayette Hotel, Long Beach, Calif., August 26–27, 1952.

Four sessions were held during the two days and 17 papers were presented. Subjects covered include both wire and radio telemetering. The first session dealt with papers on telemetering pickups. A paper on "Theory and Design of Vibrating Wire Transducers" describes a relatively new type of telemetering pickup with good stability and high-frequency response.

At the second session, three papers dealing with problems of FM-FM telemetering systems were presented. The session was concluded with a panel discussion on problems of radio telemetering. A brisk discussion from the floor resulted from the panel presentations and is included.

The third session continued the discussion of radio telemetering problems. A paper at this session described some of the problems encountered in telemetering data required for upper atmosphere research.

The final session dealt with wire telemetering. Problems of power systems, telephone systems, and petroleum production operations were discussed in four papers.

Publication S-54 is available at the price of $3.50 to members and nonmembers from:

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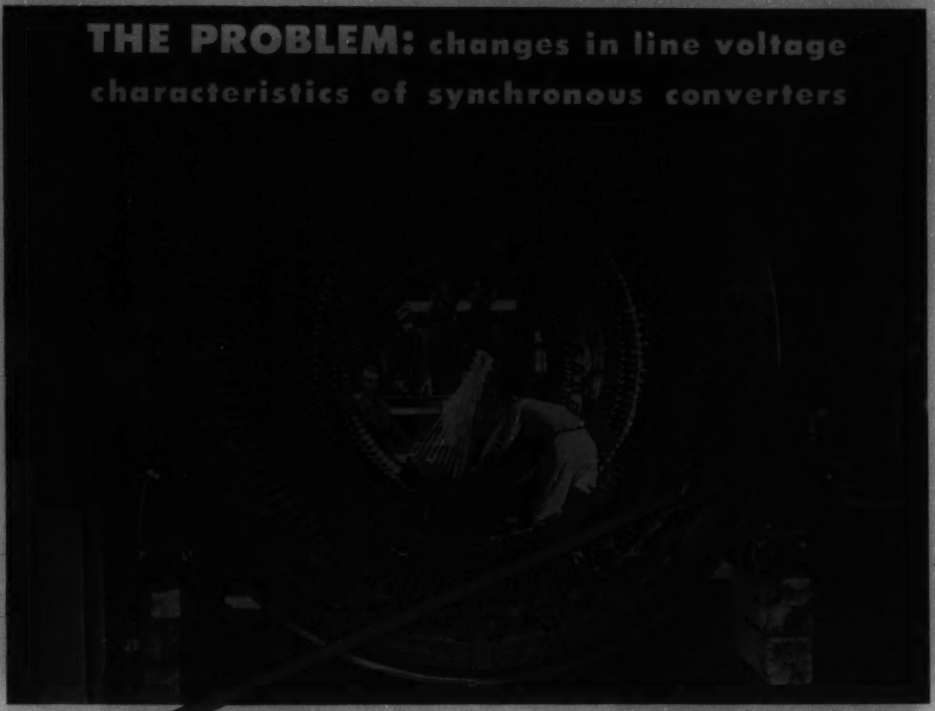
6-53

THE PROBLEM: changes in line voltage characteristics of synchronous converters



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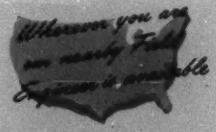

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These instruments comply with test equipment requirements of such radio interference specifications as MIL-I-6181, MIL-I-16910, PRO-MIL-STD-225, ASA C63.2, 16E4, AN-I-24a, AN-I-42, AN-I-27a, MIL-I-6722 and others.

STODDART AIRCRAFT RADIO Co., Inc.

6644-B Santa Monica Boulevard, Hollywood 38, California

(Continued from page 54A)

lists and describes 45 types. Each type is listed in numerical-alphabetical sequence, according to its type designation.

Dictionary of Carrier Terms. Definitions of 150 terms commonly found in telephone and telegraph carrier equipment literature are given in the Lenkurt Bulletin *EB-101*, "A Dictionary of Carrier Terms." The 16-page booklet also includes a general discussion of carrier equipment theory. Copies of this new publication are available from: Lenkurt Electric Company, 1101 County Road, San Carlos, Calif.

Transformers. A new line of hermetically sealed transformers, designed to *MIL-T-27* specifications, in *MIL-T-27* standard steel cases, is announced by Ferranti Electric, Inc., 30 Rockefeller Plaza, New York, N. Y. These are high-vacuum impregnated, fully tested and guaranteed. They include the specific types chosen for universal military applications, and cover a wide specification range. In the line are military standard filament transformers, military standard audio types, and also filter reactors. Detailed specifications and prices on types in the new line are contained in this new catalogue.

Control Relay. Application and design information about the recently introduced Type *N* control relay is available in booklet form from the Westinghouse Electric Corporation. Designed for remote-control operation, this new relay is used to sequence multimotor machines, to operate solenoids, and to obtain pilot control from push-button stations of electric circuits associated with such functions as temperature and pressure regulation. The Type *N* relay has a 10-ampere open rating, up to 600 volts and 6 poles, and is available in any normally open–normally closed combination. An exploded view of the relay shows its construction features as well as how easily it is disassembled. Also, pictorial instructions show how to obtain the combinations of normally open–normally closed contacts. A dimensional drawing of the relay and associated wiring circuits are provided. For a copy of this booklet, *B-5877*, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Arcaloy Stainless Steel Electrodes. A new 20-page catalogue in color is offered by the Alloy Rods Company on its complete line of Arcaloy Stainless Steel Electrodes. The catalogue includes explanation of the two basic types offered, lime coating for all-position welding with d-c reverse polarity, and alternating current–direct current for welding of chrome-nickel steels with all types of a-c or d-c welding equipment; individual descriptions of the 23 regular analyses and special analyses of Arcaloy electrodes, weld metal properties, welding procedures, electrode analysis and color charts, current ranges, and American Iron and Steel Institute type numbers. Copies of this catalogue may be secured by writing Alloy Rods Company, York, Pa., and asking for Bulletin *AR53-16*.

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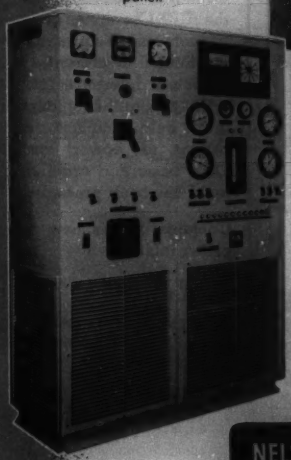

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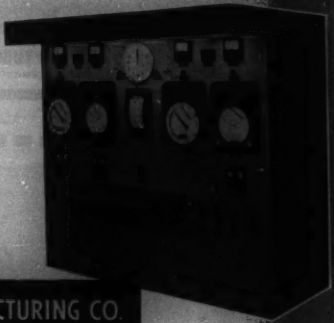

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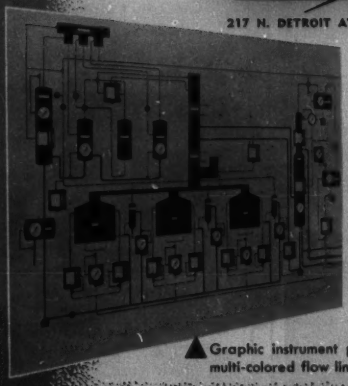

▲ Graphic instrument panel with multi-colored flow lines.

▲ Control panel [illegible] products pipeline [illegible]

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BIBLIOGRAPHY ON POWER CAPACITORS 1925-1950

This Bibliography (S-43) was prepared as an activity of the Capacitor Subcommittee of the AIEE Committee on Transmission and Distribution and is intended to present a consolidated reference to the principal significant literature in the field of capacitor applications to power circuits. Only basic and original material has been presented.

Contents of this new publication include:

(1) LIST OF PERIODICALS

(2) BIBLIOGRAPHY ON POWER CAPACITORS, catalogued into the following divisions:

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Capacitors (*their design, construction, operation, and maintenance*)

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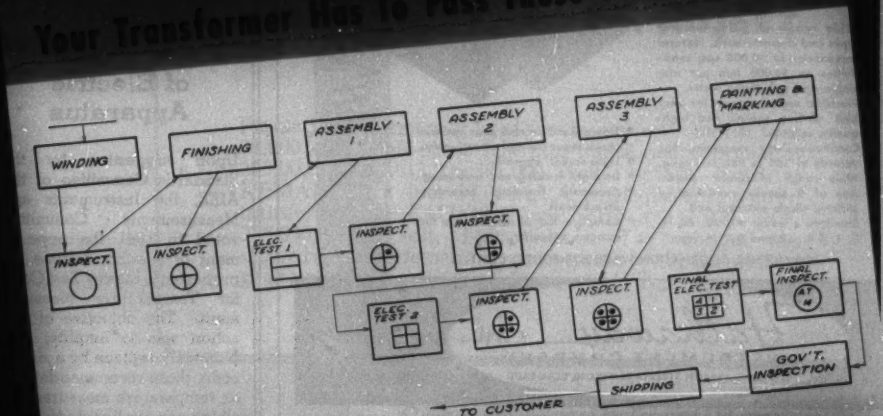

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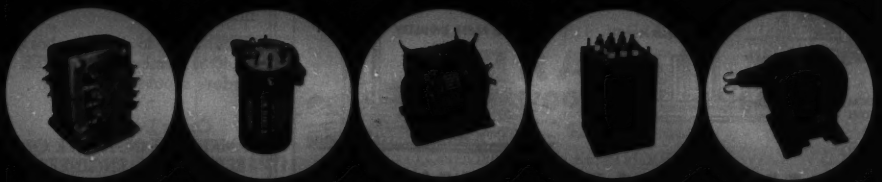

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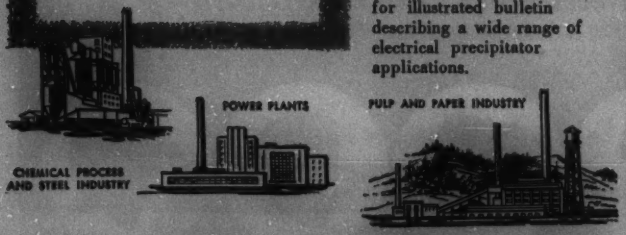

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The recommendations in this completed and approved code (number 551, effective as of August 1950) apply to the determination of operating temperature and of temperature rise of all electric machines, instruments, and apparatus in common use, where temperatures do not exceed 500 degrees centigrade. Standards pertaining to permissible temperature rise and corrections are not included.

Price: $0.80 to non-members, $0.40 to members of the AIEE. Orders should be sent to:

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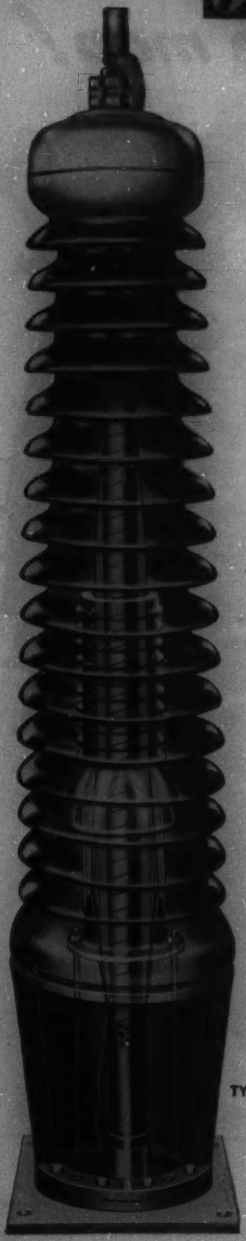
82-5

Now it's G & W for OIL & GAS FILLED

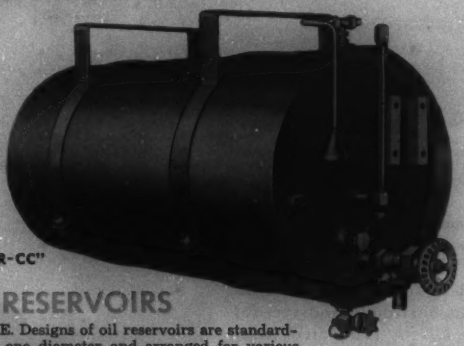


TYPE "ATA"
161 Kv.

CABLE ACCESSORIES, up to 161 Kv., formerly made by General Electric Co. were turned over to G & W on January 1, 1953. Cable manufacturers and users are assured that G & W has the qualified personnel with the necessary engineering and manufacturing experience and production facilities for properly handling this category of equipment. G & W designs of potheads in this class have proved very satisfactory and will be continued. G & W has received the G. E. patents and drawings and is now in production on oil reservoirs, relays, spreader heads, gas cabinets, valves, tapes, oil, gas and compounds, and cable joint material kits. Design details have been revised where desirable to improve the devices—for example, pressure tight housings are now fabricated from sheet or spun metal instead of castings to eliminate possibility of leaks due to porosity.

POTHEADS

Proper treatment of mechanical and electrical stresses permit the simple G & W design shown at the left. In this Type "ATA" pothead, full 200 pound pipe line oil pressure is retained by the relatively small bore porcelain shell. Stress relief cone, supplemented by porcelain stress control tube, makes efficient use of the internal diameter and length of porcelain shell—and reduces the amount of installation labor.



TYPE "R-CC"

OIL RESERVOIRS

The G. E. Designs of oil reservoirs are standardized to one diameter and arranged for various valves, filling fittings and oil level gauges as required. Two styles of interchangeable brackets for ceiling, wall or corner mounting. The three types of reservoirs are available in sizes given below.

TYPE "R-AC"-Oil in tank, gas in sealed unit cells. For feeding oil into joints and potheads on "solid" oil filled cables. Sizes 3, 5, 10 and 15 gals.

TYPE "R-CC"-Oil in cells (manifolded to cable). Oil in tank, vented to atmosphere. Same purpose as "R-AC," but for conditions which permit the use of a gravity feed reservoir. Sizes 3, 5, 10, 15 and 20 gallons.

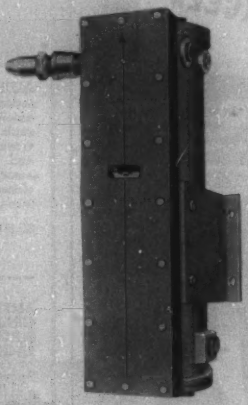
TYPE "R-DC"-Oil in cells (manifolded to cable), gas in tank. Balanced pressure type for feeding oil filled cables where gravity feed is not suitable. Sizes 3, 5, 10, 15, and 20 gallons.

SPREADER HEADS

For use with 3 conductor, shielded, lead covered cables, solid, gas or oil filled paper insulated, which are to be terminated in single conductor potheads. Made in various forms, and sizes, the Type "SH" illustrated is a typical gasketless style.

CABLE ACCESSORIES

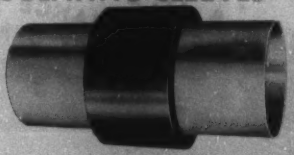
RELAYS



Relays, used in conjunction with alarm devices, give automatic warning of the existence of dangerous minimum or maximum pressure conditions. Simplified and improved functional relays of various designs are available for adaptation to the three types of oil reservoirs for low pressure oil filled cable systems—and for low, medium and high pressure gas filled cables.

The Type "EG" relay illustrated is for use with Type "R-CC" oil reservoir only. This relay has a steel ball float in a vertical brass tube and magnetic linkages which actuate the alarm circuit switches. The protective enclosure is bolted to the front of the "R-CC" reservoir.

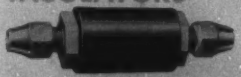
INSULATING SLEEVES



To eliminate circulating sheath currents in large size single conductor cables, insulating sleeves are used in the cable sheath or as joint sleeves to break the continuity of the cable sheath. Sections between insulators are bonded and grounded at one point only. The resultant voltage induced on the sheath is kept within safe limits and the current carrying capacity of the cable is not affected by the sheath losses.

Insulating sleeves are available in the G. E. molded insulation type (illustrated) and in the G & W soldered porcelain type.

PIPE INSULATORS



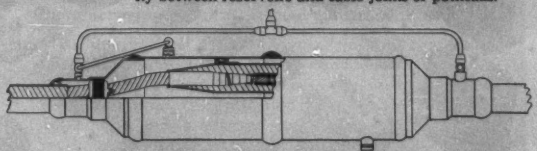
Pipe insulators, Bakelite, with flared fittings for ⅜ o.d. copper tubing, are used to break the electrical continuity between reservoirs and cable joints or potheads.

TAPES, COMPOUNDS and OILS, GAS, CABINETS, VALVES and FITTINGS

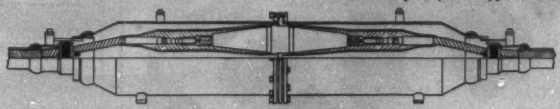
These materials and devices for use in conjunction with oil and gas filled cable terminations and joints are available from G & W for your convenience.

CABLE JOINTS

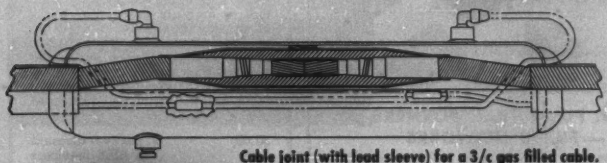
Carefully prepared designs and complete jointing material for all sizes and types of oil and gas filled cables are furnished by G & W. Joints are designed individually for specific cable installations. Simple construction from the standpoint of installation is an important consideration.



Normal joint (with copper sleeves) for a 3/c oil filled cable.



Typical stop joint for a 3/c oil filled cable.



Cable joint (with lead sleeve) for a 3/c gas filled cable.

Your orders and inquiries for oil and gas filled cable accessories received direct or through cable manufacturers will be given our careful attention.

AT 531

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STANDARD FOR SWITCHGEAR ASSEMBLIES AND METAL-ENCLOSED BUS (1-52)

AIEE Standard No. 27 (which supersedes No. 27 issued in 1942) covers assemblies of switchgear devices such as switches, interrupting devices, control, metering, protective and regulating equipment with associated interconnections, enclosed bus, and supporting structures.

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AMERICAN STANDARD GRAPHICAL SYMBOLS FOR SINGLE (ONE) LINE ELECTRICAL ENGINEERING DIAGRAMS (9-51)

Sponsored by the AIEE, the American Society of Mechanical Engineers and approved by the American Standards Association, Inc. This new standard, Y32.1.1-1951, contains graphical symbols for single (one) line electrical engineering diagrams. These diagrams indicate, by means of single lines and simplified symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein. It is intended that a single line diagram may be used to show essential components and functions in simplified form. Examples of diagrams and an index to graphical symbols are also included.

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AMERICAN STANDARD FOR CAPACITOR UNITS (12-51)

AIEE Standard No. 18 and American Standards Association (ASA) No. C55.1 1951 supersedes the C55 issued in 1934. Sponsored by the AIEE and approved by the ASA, the standards in this section apply to shunt and series-connected capacitor units on a-c power transmission and distribution systems at nominal frequencies of 60 cycles or below, for the purpose of modifying the performance of the circuits at normal frequency.

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The above new standards may be obtained from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York 18, N. Y.

6-53

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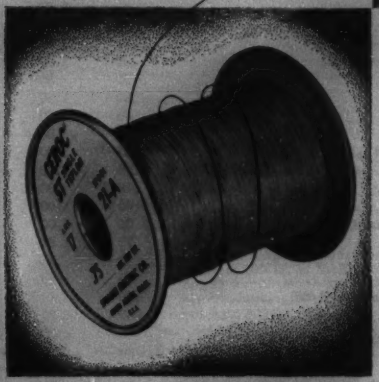

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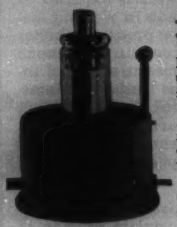

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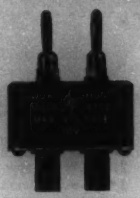
452A-95A Adaptor: To connect -hp- 410B probe to shielded connector of -hp- 452A. $10.00



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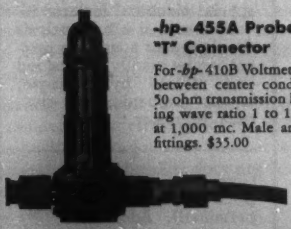

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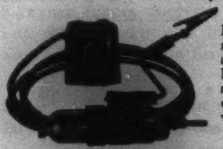
For -hp- 410B Voltmeter. Measures voltages between center conductor and sheath of 50 ohm transmission line. Maximum standing wave ratio 1 to 1.1 at 500 mc; 1 to 1.2 at 1,000 mc. Male and female Type "N" fittings. $35.00

-hp- 454A Capacitive Voltage Divider



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MIGHTY MITE THERMAL CONTROLS

ELECTRICAL INDUSTRIES PRODUCTION COMPANY

Power Supply for Resistance Welding Machines

(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940–1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

Copies are available for the price of $1.00 (no discounts permitted). Address:

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6-53

Preclosed contacts on Westinghouse relay give you instantaneous reclosure

Instantaneous Reclosure—Westinghouse development engineering on the RC reclosing relay now makes possible a truly instantaneous first reclosure. New *preclosed* contacts were developed to achieve this high-speed action. The time saved is invaluable—it could, for instance, mean the difference between saving and losing some important industrial loads.

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Lockout of Instantaneous Elements—Another feature provided by the redesigned RC relay is lockout of the instantaneous elements in protective relays. This is essential, for example, when fuses are used to protect branches of a main feeder. If a fault on a branch feeder does not clear with the first trip-out, the RC relay will lock out the instantaneous element, allowing the fuse to clear the fault on the next reclosure.

Relay Engineering—Out of the Westinghouse relay laboratory in Newark, N. J., has come, through the years, a constant parade of relay "firsts". For the finest relay engineering, the very latest in relay developments, look to Westinghouse.

Free Literature—For more information on the RC relay, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-40448

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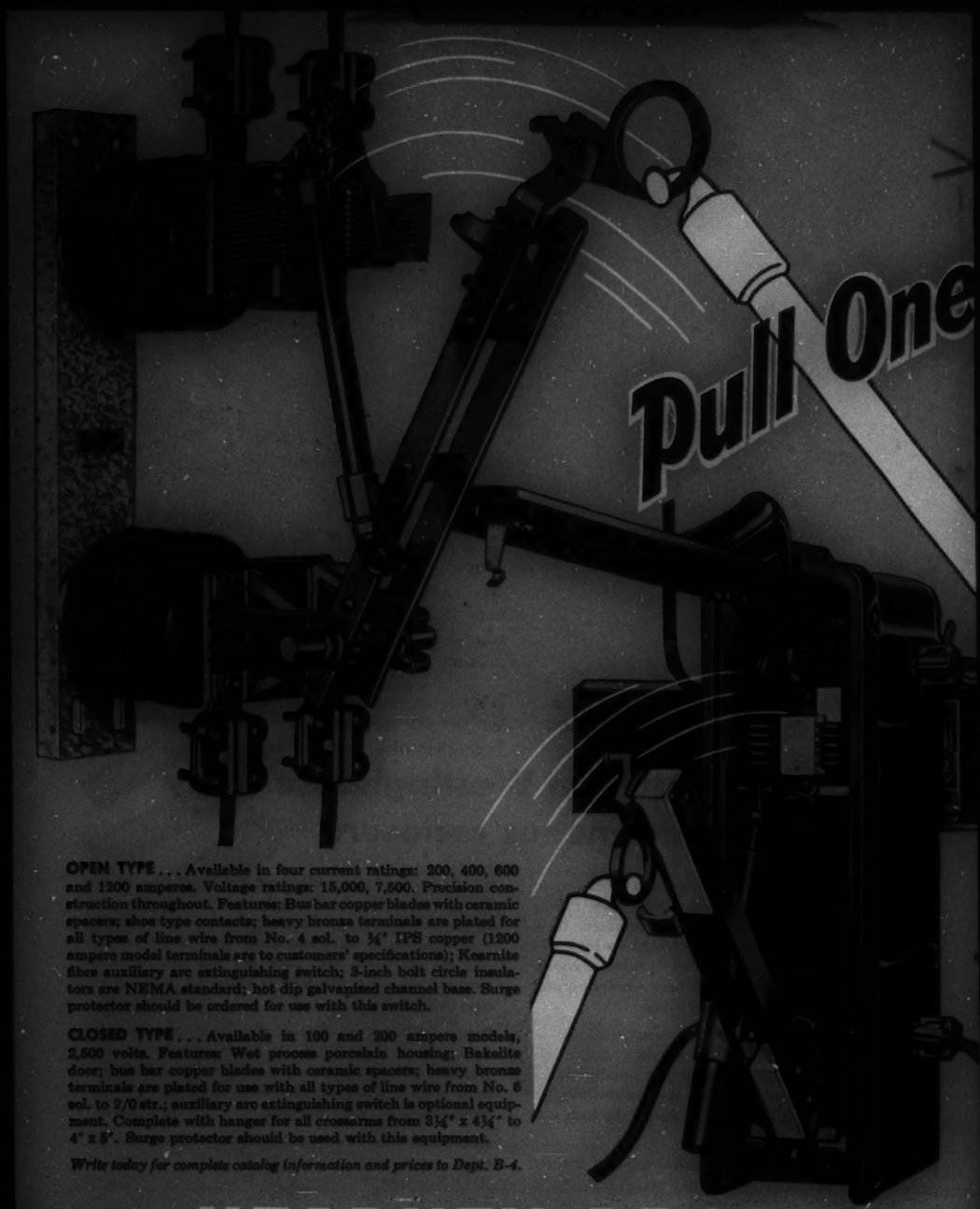

OPEN TYPE . . . Available in four current ratings: 200, 400, 600 and 1200 amperes. Voltage ratings: 15,000, 7,500. Precision construction throughout. Features: Bus bar copper blades with ceramic spacers; shoe type contacts; heavy bronze terminals are plated for all types of line wire from No. 4 sol. to ¼" IPS copper (1200 ampere model terminals are to customers' specifications); Kearnite fibre auxiliary arc extinguishing switch; 3-inch bolt circle insulators are NEMA standard; hot dip galvanized channel base. Surge protector should be ordered for use with this switch.

CLOSED TYPE . . . Available in 100 and 200 ampere models, 2,500 volts. Features: Wet process porcelain housing; Bakelite door; bus bar copper blades with ceramic spacers; heavy bronze terminals are plated for use with all types of line wire from No. 6 sol. to 2/0 str.; auxiliary arc extinguishing switch is optional equipment. Complete with hanger for all crossarms from 3¼" x 4¼" to 4" x 5". Surge protector should be used with this equipment.

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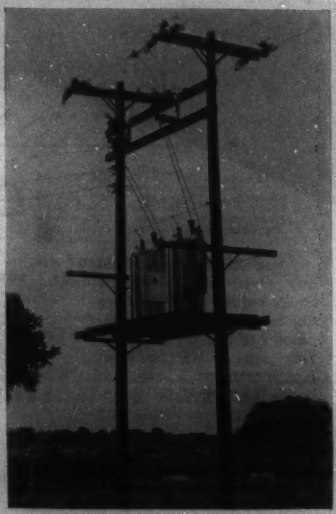

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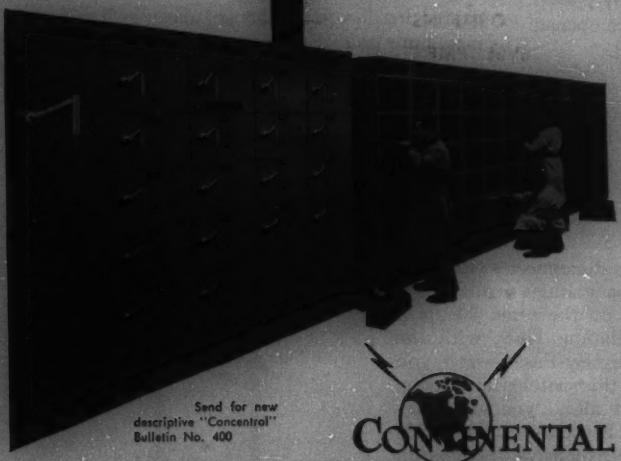

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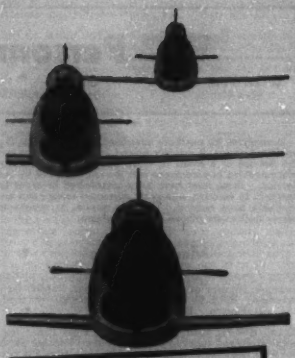

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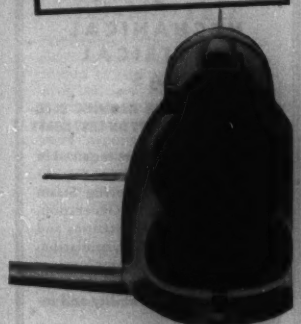

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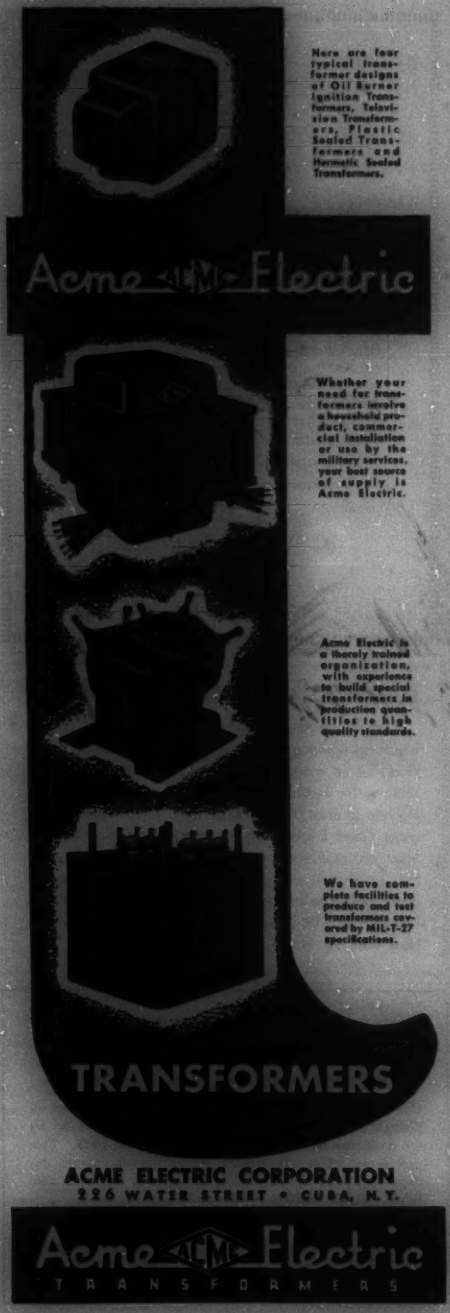
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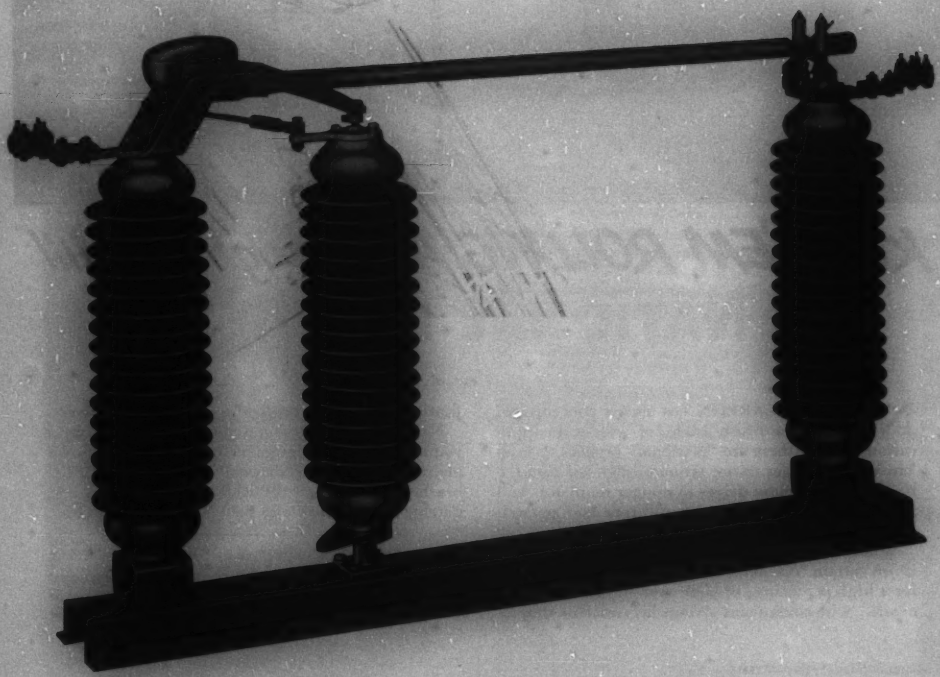

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